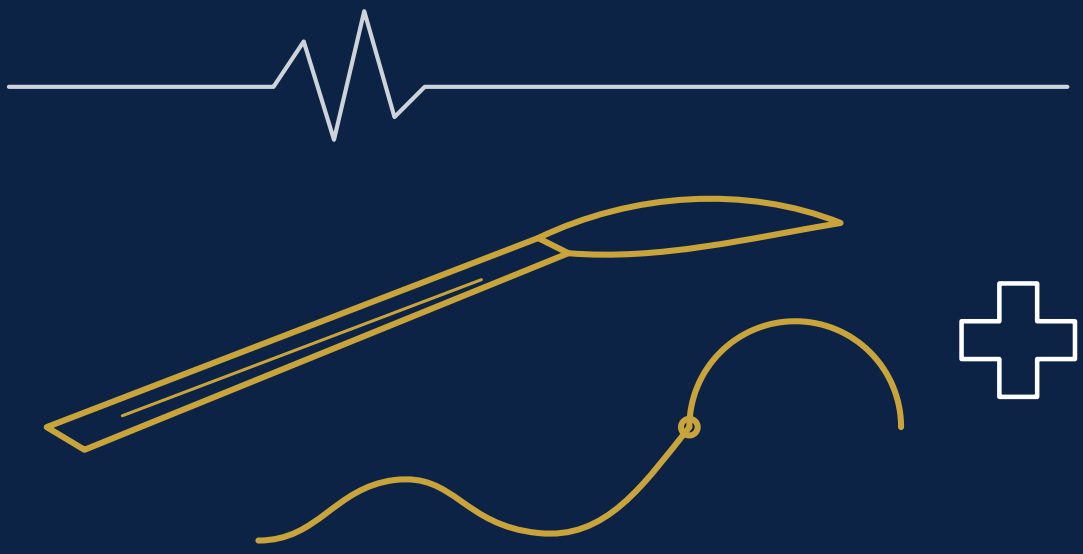
FINAL YEAR MBBS · REVISION MINI-BOOK

# Surgery in General

Basic Principles of Surgery for Rapid Pre-Examination Revision

Based on *Bailey & Love's Short Practice of Surgery*, 28th Edition

Tables · Algorithms · Line Diagrams · 120 Scenario-based One-Best MCQs



Organized by

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## Preface

This mini-book has been organized for final year MBBS students who need to revise the **general principles of surgery** in the last days before their professional examination. It follows the opening, "Basic Principles" section of *Bailey & Love's Short Practice of Surgery* (28th Edition), together with the general chapters on trauma and burns. Specialty (regional) surgery is deliberately excluded.

The text is written in short, examinable statements. Each chapter contains key-point boxes, comparison tables, management algorithms, simple line diagrams, "exam pearls" and memory aids. Every chapter ends with **10 scenario-based one-best-answer MCQs**, each with five options listed alphabetically, followed by an answer key with a brief explanation.

This book is a revision tool, not a substitute for the parent textbook. Drug doses and protocols should always be checked against current local guidelines before clinical use.

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**How to use this book**

- **First pass (1 week before):** read each chapter fully, then attempt its MCQs without looking at the key.
- **Second pass (2–3 days before):** read only the boxes, tables, algorithms and exam pearls.
- **Last night:** re-attempt only the MCQs you got wrong and re-read their explanations.

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9 Care in the Operating Theatre and Principles of Minimal Access Surgery

10 Post-operative Care and Complications

11 Early Assessment and Management of Trauma

12 Burns

Reference: O'Connell PR, McCaskie AW, Sayers RD (eds). *Bailey & Love's Short Practice of Surgery*, 28th Edition. CRC Press, 2023.

CHAPTER 1

# The Metabolic Response to Injury

**Key points**

- Any injury (trauma, surgery, burns, sepsis) triggers a **stereotyped neuroendocrine, cytokine and metabolic response** aimed at survival.
- Homeostasis is preserved at a cost: **catabolism, insulin resistance, salt and water retention**.
- The response is proportional to the **severity of the insult**; minimal-access surgery and good analgesia reduce it.
- Modern peri-operative care (**ERAS**) aims to attenuate this response and speed recovery.

## 1. Phases of the response

Classically described by Cuthbertson: an early **ebb phase** followed by a **flow phase** (catabolic then anabolic).

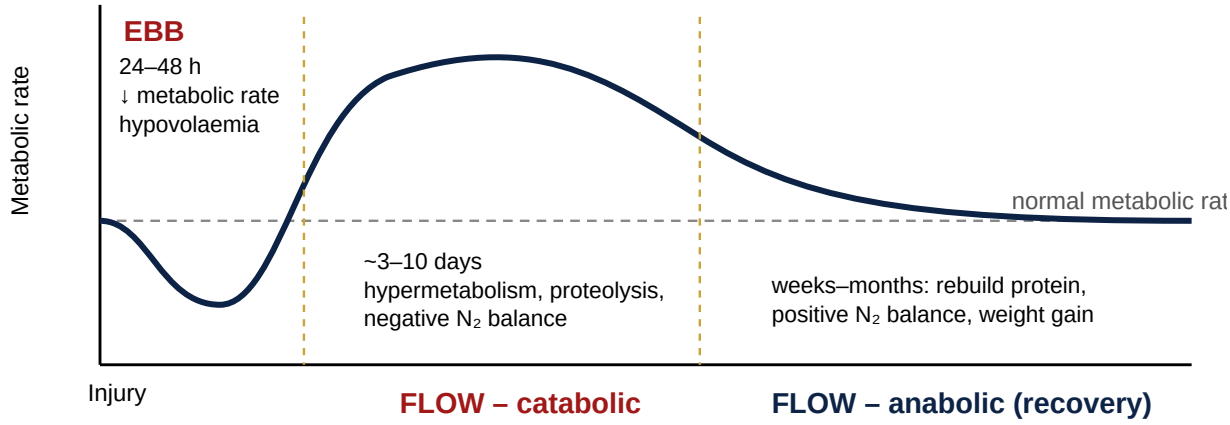



*Figure 1.1 — Ebb and flow phases of the metabolic response to injury (line diagram).*

## 2. Mediators of the response

| System | Main changes | Effect |
|---|---|---|
| Afferent signals | Nociceptive nerve impulses, cytokines from the wound, hypovolaemia (baroreceptors) | Activate hypothalamus |
| Neuroendocrine (HPA axis, sympathetic) | ↑ ACTH, cortisol, catecholamines, glucagon, GH, ADH, aldosterone; ↓ insulin action; ↓ $T_3$ ("sick euthyroid"), ↓ testosterone | Hyperglycaemia, lipolysis, proteolysis, $Na^+$/water retention |
| Cytokines | IL-1, IL-6, TNF-α (pro-inflammatory) → later IL-4, IL-10 (anti-inflammatory) | Fever, acute-phase response |
| Acute-phase proteins (liver) | ↑ CRP, fibrinogen, ferritin, α1-antitrypsin; ↓ albumin, transferrin | CRP is a useful marker; albumin falls |
| Endothelium / vascular | Nitric oxide, prostanoids, ↑ capillary permeability | Oedema, "third-space" loss |

**Exam pearl — SIRS and CARS**

The pro-inflammatory **SIRS** is counterbalanced by an anti-inflammatory **CARS** (compensatory anti-inflammatory response). Excess SIRS → MODS; excess CARS → immunosuppression and late infection. A second insult ("**second hit**", e.g. re-operation or sepsis) on a primed system can trigger MODS.

| SIRS criteria (≥ 2) | qSOFA (Sepsis-3; ≥ 2 suggests poor outcome) |
|---|---|
| Temperature > 38 °C or < 36 °C<br>Heart rate > 90/min<br>RR > 20/min or $PaCO_2$ < 4.3 kPa<br>WBC > 12 or < 4 × $10^9$/L | Respiratory rate ≥ 22/min<br>Altered mentation (GCS < 15)<br>Systolic BP ≤ 100 mmHg<br>Sepsis = infection + life-threatening organ dysfunction (↑ SOFA ≥ 2) |

## 3. Metabolic changes

| Substrate | Change after injury |
|---|---|
| Carbohydrate | Hyperglycaemia from glycogenolysis and gluconeogenesis; **peripheral insulin resistance**. Liver glycogen exhausted within ~24 h. |
| Protein | Skeletal muscle breakdown (up to 0.5 kg/day after major injury) releases **glutamine and alanine** for gluconeogenesis, acute-phase proteins and immune cells → **negative nitrogen balance**, muscle wasting. |
| Fat | Lipolysis → free fatty acids and glycerol; fat becomes the main energy source. |
| Water and salt | ADH and aldosterone → **oliguria, $Na^+$ and water retention, $K^+$ loss** in urine. Post-operative patients are prone to dilutional hyponatraemia if given excess hypotonic fluid. |
| Energy expenditure | ↑ resting energy expenditure: elective surgery ~10%, multiple trauma/sepsis 20–50%, major burns up to 100%. |

## 4. Starvation versus injury

| Feature | Simple starvation | Injury / sepsis |
|---|---|---|
| Metabolic rate | Falls (adaptive) | Rises (hypermetabolism) |
| Main fuel | Fat → ketones (keto-adaptation) | Fat + glucose; ketosis suppressed |
| Protein breakdown | Reduced (protein sparing) | Increased; **not reversed by feeding alone** |
| Insulin | Low, sensitive | High, resistant |
| Response to nutrition | Rapidly reversed | Only attenuated |

## 5. Factors that modify the response

- Severity and duration of injury (major > minor)
- Ongoing infection, ischaemia, pain
- Age, frailty, pre-existing malnutrition
- Hypothermia and hypovolaemia
- Minimal-access (laparoscopic) surgery ↓ response
- Regional (epidural) anaesthesia blocks afferent signals and blunts cortisol/glucose rise
- Avoidance of prolonged fasting
- Early enteral nutrition

## 6. Enhanced Recovery After Surgery (ERAS)

**Pre-operative**
Counselling, prehabilitation, stop smoking, correct anaemia, **carbohydrate loading**, clear fluids until 2 h, no routine bowel preparation

**Intra-operative**
Minimal access, regional/short-acting anaesthesia, goal-directed fluids, **normothermia**, avoid routine drains and NG tubes

**Post-operative**
Opioid-sparing multimodal analgesia, **early oral feeding**, **early mobilisation**, early catheter removal, PONV prophylaxis

Benefits: shorter hospital stay, fewer complications, faster return of gut function — without increasing readmissions.

## 7. Clinical consequences of an unchecked response

- **Muscle wasting and fatigue** — delayed mobilisation, chest infection, prolonged convalescence.
- **Hyperglycaemia** — impaired immunity and wound healing.
- **Fluid overload / hyponatraemia** — gut oedema, ileus, anastomotic problems.
- **MODS** — sequential failure of lungs (ARDS), kidneys, liver, gut, heart and brain.

**Memory aid — hormones that RISE after injury: "CAG-GAA"**
**C**ortisol, **A**CTH, **G**lucagon, **G**rowth hormone, **A**DH, **A**ldosterone (+ catecholamines). Insulin rises but is ineffective (resistance); $T_3$ and testosterone fall.

## Chapter 1 — Self-assessment MCQs (one best answer)

Choose the single best answer. Options are listed alphabetically.

**1.1** A 45-year-old man undergoes an open right hemicolectomy. On the first post-operative day his urine output is 25 mL/h, serum sodium 131 mmol/L and urinary sodium is low. He is haemodynamically stable. Which hormonal change best explains this pattern?

A. Increased antidiuretic hormone and aldosterone secretion
B. Increased atrial natriuretic peptide secretion
C. Increased insulin sensitivity
D. Reduced cortisol secretion
E. Reduced renin secretion

**1.2** A 30-year-old man with multiple long-bone fractures is in the intensive care unit on day 4. His 24-hour urinary urea is markedly increased despite adequate enteral feeding. What is the main source of this nitrogen loss?

A. Breakdown of hepatic glycogen
B. Breakdown of skeletal muscle protein
C. Hepatic synthesis of albumin
D. Lipolysis of adipose tissue
E. Renal tubular damage

**1.3** A 60-year-old woman is starved for 5 days with no injury, while a 60-year-old man is septic after a perforated sigmoid colon. Which feature is present in the septic man but NOT in simple starvation?

A. Increased ketone body utilisation by the brain
B. Increased resting energy expenditure
C. Lipolysis of adipose stores
D. Low circulating insulin
E. Reduced protein breakdown

**1.4** Forty-eight hours after laparotomy for a perforated duodenal ulcer, a patient's serum albumin has fallen from 40 to 28 g/L. He has received modest fluids and is not proteinuric. Which is the most likely explanation?

A. Acute protein malnutrition
B. Haemodilution by intravenous fluid alone
C. Increased capillary permeability and reduced hepatic synthesis
D. Loss of albumin into the peritoneal drain
E. Nephrotic-range proteinuria

**1.5** A trauma patient has temperature 38.6 °C, pulse 112/min, respiratory rate 24/min and white cell count 15 × $10^9$/L, with no source of infection identified. Which term best describes this state?

A. Compensatory anti-inflammatory response syndrome
B. Multiple organ dysfunction syndrome
C. Sepsis
D. Septic shock
E. Systemic inflammatory response syndrome

**1.6** A 70-year-old man is listed for elective open aortic surgery. The anaesthetist plans a thoracic epidural in addition to general anaesthesia, partly to modify the stress response. Which effect of the epidural is most responsible for this?

A. Blockade of afferent neural signals from the wound
B. Direct suppression of hepatic acute-phase protein synthesis
C. Direct suppression of interleukin-6 release from the wound
D. Increased insulin secretion
E. Prevention of hypothermia

**1.7** Within the ERAS pathway for a 52-year-old non-diabetic woman undergoing elective colectomy, which pre-operative measure is primarily intended to reduce post-operative insulin resistance?

A. Mechanical bowel preparation the day before
B. Nil by mouth from midnight
C. Pre-operative chlorhexidine shower
D. Pre-operative oral carbohydrate loading 2 hours before induction
E. Routine nasogastric decompression

**1.8** A 35-year-old man with 40% total body surface area burns has a resting energy expenditure nearly double the predicted value on day 7. Which mediator plays the dominant role in this hypermetabolism?

A. Antidiuretic hormone
B. Catecholamines
C. Growth hormone
D. Insulin
E. Thyroxine ($T_4$)

**1.9** A patient survives emergency surgery for a ruptured abdominal aortic aneurysm and is stabilising on day 3. On day 5 he develops pneumonia and then progressive renal and hepatic failure. Which concept best explains this deterioration?

A. Compensatory anti-inflammatory response syndrome alone
B. Ebb phase of the metabolic response
C. Refeeding syndrome
D. Second-hit phenomenon leading to MODS
E. Sick euthyroid syndrome

**1.10** Six hours after major trauma, a patient is cold, peripherally vasoconstricted and has reduced oxygen consumption despite resuscitation in progress. Which phase of the metabolic response is he in?

A. Anabolic flow phase
B. Catabolic flow phase
C. Ebb phase
D. Recovery phase
E. Starvation phase

## Answer key with explanations

**1.1 — A** (Increased antidiuretic hormone and aldosterone secretion). Post-injury ADH and aldosterone cause water and sodium retention with oliguria; free-water retention (ADH) produces mild dilutional hyponatraemia. ANP would cause natriuresis, not retention.

**1.2 — B** (Breakdown of skeletal muscle protein). In the catabolic flow phase skeletal muscle is broken down to release amino acids (glutamine, alanine) for gluconeogenesis and acute-phase protein synthesis, causing negative nitrogen balance. Feeding attenuates but does not abolish this.

**1.3 — B** (Increased resting energy expenditure). Starvation is an adaptive state with a falling metabolic rate, keto-adaptation and protein sparing. Injury/sepsis causes hypermetabolism with increased energy expenditure and protein catabolism that is not suppressed by feeding.

**1.4 — C** (Increased capillary permeability and reduced hepatic synthesis). Albumin is a negative acute-phase protein: synthesis falls as the liver prioritises CRP and fibrinogen, and increased capillary permeability shifts albumin into the interstitium. Malnutrition takes weeks to lower albumin; some dilution contributes but is not the main cause.

**1.5 — E** (Systemic inflammatory response syndrome). Two or more SIRS criteria without confirmed infection = SIRS. Sepsis requires infection with organ dysfunction; septic shock additionally needs vasopressors and lactate > 2 mmol/L despite fluids. MODS implies organ failure.

**1.6 — A** (Blockade of afferent neural signals from the wound). Neural afferents from the injured area are a major trigger of the hypothalamic–pituitary and sympathetic response. Epidural blockade reduces the cortisol and glucose surge; it has little effect on wound cytokine (IL-6) release.

**1.7 — D** (Pre-operative oral carbohydrate loading 2 hours before induction). Carbohydrate loading avoids entering surgery in a fasted catabolic state and has been shown to reduce post-operative insulin resistance. Overnight fasting worsens it; bowel preparation and NG tubes are not recommended routinely.

**1.8 — B** (Catecholamines). Sustained catecholamine release is the main driver of hypermetabolism after major burns and trauma (β-blockade with propranolol reduces it). $T_3$ levels actually fall (sick euthyroid); insulin is high but ineffective.

**1.9 — D** (Second-hit phenomenon leading to MODS). The initial insult primes the inflammatory system; a second insult (infection, re-operation) triggers an exaggerated response and multiple organ dysfunction syndrome. CARS predisposes to infection but does not itself explain the organ failure cascade.

**1.10 — C** (Ebb phase). The ebb phase (first 24–48 h) is characterised by reduced metabolic rate and oxygen consumption, hypothermia and hypovolaemia. Once resuscitated, the patient enters the hypermetabolic catabolic flow phase.

CHAPTER 2

# Shock and Blood Transfusion

**Key points**

- **Shock** = systemic hypoperfusion causing inadequate tissue oxygen delivery → anaerobic metabolism, lactic acidosis, cell death.
- Hypotension is a **late** sign; tachycardia, cool peripheries, tachypnoea, oliguria and rising lactate appear earlier.
- Haemorrhage is the commonest cause of shock in surgical and trauma patients until proven otherwise.
- Treat the cause (stop bleeding, drain sepsis) while restoring oxygen delivery.

**Oxygen delivery**

$DO_2$ = Cardiac output × Arterial $O_2$ content | CO = HR × Stroke volume | $CaO_2 \approx 1.34 \times Hb \times SaO_2$ (+ small dissolved $O_2$)

→ Improve $DO_2$ by restoring volume (preload), Hb, $SaO_2$ and contractility.

## 1. Classification of shock

| Type | Causes | CO | SVR | CVP/JVP |
|---|---|---|---|---|
| **Hypovolaemic** | Haemorrhage, burns, vomiting, diarrhoea, fistula, third-space loss | ↓ | ↑ | ↓ |
| **Cardiogenic** | Myocardial infarction, arrhythmia, myocarditis, valve failure | ↓ | ↑ | ↑ |
| **Obstructive** | Tension pneumothorax, cardiac tamponade, massive pulmonary embolism | ↓ | ↑ | ↑ |
| **Distributive** | Septic, anaphylactic, neurogenic (spinal cord injury above T6) | ↑ / N (↓ late) | ↓ | ↓ / N |
| **Endocrine** | Adrenal (Addisonian) crisis, hypothyroidism, thyroid storm | variable | | |

**Exam pearl**

**Neurogenic shock** = hypotension with **bradycardia** and warm peripheries (loss of sympathetic tone). Early septic shock = hypotension with warm, vasodilated peripheries and bounding pulse.

## 2. Classes of haemorrhagic shock (ATLS, 70-kg adult)

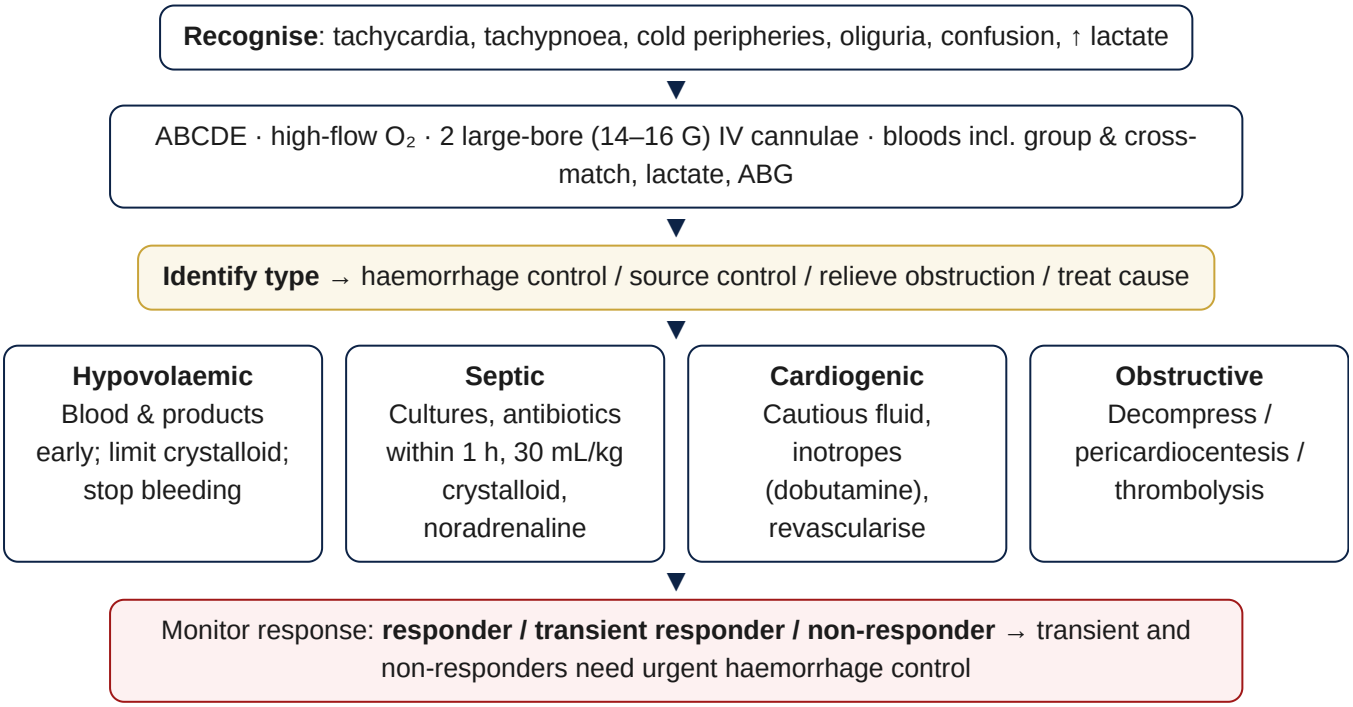
| | Class I | Class II | Class III | Class IV |
|---|---|---|---|---|
| Blood loss (%) | < 15% | 15–30% | 30–40% | > 40% |
| Blood loss (mL) | < 750 | 750–1500 | 1500–2000 | > 2000 |
| Pulse (/min) | < 100 | 100–120 | 120–140 | > 140 |
| Systolic BP | Normal | Normal | ↓ | ↓↓ |
| Pulse pressure | Normal/↑ | ↓ | ↓ | ↓ |
| Resp. rate | 14–20 | 20–30 | 30–40 | > 35 |
| Urine (mL/h) | > 30 | 20–30 | 5–15 | Negligible |
| Mental state | Slightly anxious | Mildly anxious | Anxious, confused | Confused, lethargic |

The first measurable fall in blood pressure usually occurs in Class III (≈ 30% loss). A narrowed pulse pressure is an early sign. Beta-blockers, pacemakers, athletes and the elderly may not mount a tachycardia.

## 3. Compensated shock and its markers

- **Occult hypoperfusion**: normal vital signs but persistent tissue hypoxia (↑ lactate, base deficit) — associated with ↑ MODS and mortality.
- Markers: serum **lactate > 2 mmol/L**, **base deficit** worse than −5, mixed venous $O_2$ saturation, urine output < 0.5 mL/kg/h.
- Endpoints of resuscitation: normal lactate and base deficit, urine output ≥ 0.5 mL/kg/h, normal mentation.

## 4. Management of shock — algorithm



## Fluid challenge

250–500 mL of crystalloid given rapidly; a rise in BP/fall in HR that is sustained suggests volume deficit. A transient response implies ongoing loss.

## Damage-control resuscitation (major haemorrhage)

- **Permissive (hypotensive) resuscitation**: accept a lower BP (systolic ~80–90 mmHg, palpable radial pulse) until bleeding is controlled — *not* in head injury.
- **Haemostatic resuscitation**: early red cells, plasma and platelets in near 1:1:1 ratio; minimise crystalloid.
- **Tranexamic acid** 1 g IV over 10 min within 3 h of injury, then 1 g over 8 h (CRASH-2).
- Prevent the **lethal triad**.

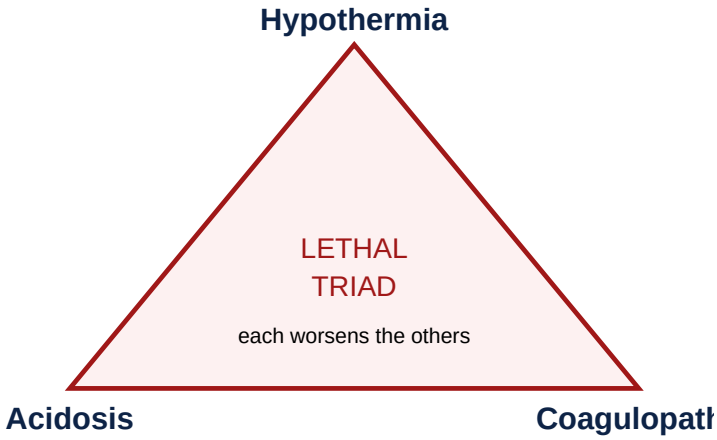



*Figure 2.1 — The lethal triad of trauma.*

## Vasoactive drugs

| Drug | Main action | Main use |
|---|---|---|
| Noradrenaline | $\alpha_1 > \beta_1$ — vasoconstrictor | First-line in septic shock |
| Adrenaline | α + β | Anaphylaxis (0.5 mg IM, 1:1000), cardiac arrest |
| Dobutamine | $\beta_1$ — inotrope | Cardiogenic shock |
| Vasopressin | $V_1$ — vasoconstrictor | Adjunct in refractory septic shock |

## 5. Blood and blood products

| Product | Storage | Shelf life | Indication / notes |
|---|---|---|---|
| Packed red cells | 2–6 °C | ~35–42 days | Anaemia, haemorrhage. One unit raises Hb by ~10 g/L in adults |
| Platelets | 20–24 °C, agitated | 5–7 days | Thrombocytopenia with bleeding; < 50 × $10^9$/L before surgery. Highest risk of **bacterial contamination** |
| Fresh frozen plasma | ≤ −25 °C | ~2 years | Coagulopathy, massive transfusion. AB plasma = universal donor |
| Cryoprecipitate | ≤ −25 °C | ~2 years | Rich in **fibrinogen**, factor VIII, vWF, factor XIII — use when fibrinogen < 1.5 g/L |
| Prothrombin complex concentrate | Room temp. | — | Rapid reversal of warfarin (factors II, VII, IX, X) with IV vitamin K |

**Transfusion threshold:** restrictive — Hb < 70 g/L in most stable patients (70–80 g/L if cardiovascular disease). Emergency un-cross-matched blood: **O RhD-negative** (O-positive acceptable in adult males).

### Complications of transfusion

| Complication | Key features |
|---|---|
| Acute haemolytic reaction | ABO incompatibility (clerical error); fever, loin pain, hypotension, haemoglobinuria, DIC — stop transfusion immediately |
| Febrile non-haemolytic | Commonest; antibodies to donor leucocytes; fever without haemodynamic upset |
| Allergic / anaphylactic | Urticaria → anaphylaxis (IgA-deficient recipients) |
| TRALI | Non-cardiogenic pulmonary oedema within 6 h; donor anti-HLA antibodies; normal CVP |
| TACO | Circulatory overload in elderly/cardiac patients; raised JVP, responds to diuretics |
| Delayed haemolytic | 5–10 days later; falling Hb, jaundice |
| Infection | Bacterial (platelets), HBV, HCV, HIV, malaria, CMV |
| Massive transfusion | Hypothermia, dilutional coagulopathy, thrombocytopenia, **hypocalcaemia (citrate)**, hyperkalaemia, acidosis |

**Definition — massive transfusion**
Replacement of one blood volume in 24 h, or 50% of blood volume in 3 h, or > 4 units in 1 h, or blood loss > 150 mL/min. Activate the **major haemorrhage protocol**.

## Chapter 2 — Self-assessment MCQs (one best answer)

Choose the single best answer. Options are listed alphabetically.

**2.1** A 28-year-old motorcyclist has a closed femoral shaft fracture. Pulse 125/min, BP 100/80 mmHg, RR 32/min, urine output 10 mL/h and he is anxious and confused. Estimate his blood loss.

A. No significant blood loss
B. Less than 750 mL
C. 750–1500 mL
D. 1500–2000 mL
E. More than 2000 mL

**2.2** A 22-year-old man falls from a horse. He is hypotensive (80/50 mmHg) with pulse 52/min, warm dry peripheries and absent sensation below the nipples. Which type of shock is most likely?

A. Cardiogenic
B. Hypovolaemic
C. Neurogenic
D. Obstructive
E. Septic

**2.3** A 65-year-old man on day 5 after anterior resection is confused with BP 82/45 mmHg, pulse 118/min, warm peripheries, temperature 39 °C and lactate 5 mmol/L. After 30 mL/kg crystalloid his MAP remains 55 mmHg. What is the most appropriate next drug?

A. Adrenaline
B. Dobutamine
C. Dopamine
D. Noradrenaline
E. Vasopressin

**2.4** A 40-year-old woman with a splenic laceration has pulse 105/min after a 1 L crystalloid bolus; it falls briefly to 90/min, then rises again to 115/min with BP dropping. What does this response indicate?

A. Adequate resuscitation
B. Cardiogenic component
C. Need for further crystalloid only
D. Ongoing haemorrhage (transient responder)
E. Septic shock

**2.5** Thirty minutes into a transfusion of packed red cells, a post-operative patient develops fever, loin pain, hypotension and dark urine. What is the most likely cause?

A. ABO-incompatible transfusion
B. Bacterial contamination of the unit
C. Febrile non-haemolytic reaction
D. Transfusion-associated circulatory overload
E. Transfusion-related acute lung injury

**2.6** A 70-year-old man receives 2 units of red cells after hip surgery. Four hours later he is breathless with bilateral crackles, raised JVP, BP 170/95 mmHg and improves rapidly with furosemide. What is the diagnosis?

A. Acute haemolytic reaction
B. Allergic reaction
C. Anaphylaxis
D. Transfusion-associated circulatory overload
E. Transfusion-related acute lung injury

**2.7** During a laparotomy for trauma, a patient receives 14 units of red cells in 3 hours. He develops perioral tingling, prolonged QT on the monitor and hypotension. Which is the most likely cause?

A. Hyperkalaemia
B. Hypocalcaemia
C. Hypokalaemia
D. Hypomagnesaemia
E. Hypothermia

**2.8** A 32-year-old man is bleeding after a stab wound to the abdomen. Fibrinogen is 0.9 g/L despite 4 units of FFP. Which blood component is most appropriate to correct this?

A. Cryoprecipitate
B. Factor VIIa
C. Fresh frozen plasma
D. Platelet concentrate
E. Prothrombin complex concentrate

**2.9** A 25-year-old man with a gunshot wound to the abdomen has been bleeding for 2 hours. Which pharmacological intervention has been shown to reduce mortality in bleeding trauma patients when given early?

A. Aprotinin
B. Desmopressin
C. Recombinant factor VIIa
D. Tranexamic acid
E. Vitamin K

**2.10** A 58-year-old man, 12 hours after a Whipple's operation, has pulse 92/min, BP 128/76 mmHg, urine output 40 mL/h, but lactate 4.2 mmol/L and base deficit −7. What is the best interpretation?

A. Adequate resuscitation
B. Cardiogenic shock
C. Normal post-operative response
D. Occult hypoperfusion
E. Over-resuscitation

## Answer key with explanations

**2.1 — D** (1500–2000 mL). Tachycardia 120–140, fall in systolic BP, RR 30–40, urine 5–15 mL/h and confusion = Class III haemorrhage (30–40%, 1500–2000 mL). Class II would have normal systolic BP.

**2.2 — C** (Neurogenic). High spinal cord injury (above T6) removes sympathetic tone: hypotension with bradycardia and warm peripheries. Hypovolaemic shock would give tachycardia and cold peripheries — but always exclude coexisting haemorrhage.

**2.3 — D** (Noradrenaline). Septic shock with fluid-refractory hypotension: noradrenaline is the first-line vasopressor (target MAP ≥ 65 mmHg). Vasopressin is an adjunct when noradrenaline requirements are high; dobutamine is an inotrope for low cardiac output.

**2.4 — D** (Ongoing haemorrhage (transient responder)). A transient response indicates continuing blood loss; she needs blood products and urgent haemorrhage control (surgery or angioembolisation). More crystalloid alone worsens dilution and coagulopathy.

**2.5 — A** (ABO-incompatible transfusion). Acute intravascular haemolysis from ABO incompatibility (usually clerical error) causes fever, loin pain, hypotension and haemoglobinuria. Bacterial contamination also causes fever and shock but not haemoglobinuria; it is more typical of platelets.

**2.6 — D** (Transfusion-associated circulatory overload). TACO: hypertension, raised JVP and pulmonary oedema that responds to diuretics, typically in elderly patients with cardiac disease. TRALI is non-cardiogenic (normal JVP, often hypotension) and does not respond to diuretics.

**2.7 — B** (Hypocalcaemia). Citrate anticoagulant in stored blood chelates ionised calcium during massive transfusion, causing tingling, prolonged QT and myocardial depression. Hyperkalaemia also occurs but produces peaked T waves, not paraesthesia with long QT.

**2.8 — A** (Cryoprecipitate). Cryoprecipitate is the concentrated source of fibrinogen (with factor VIII, vWF, XIII) and is indicated when fibrinogen < 1.5 g/L in major haemorrhage. FFP contains fibrinogen but in much lower concentration.

**2.9 — D** (Tranexamic acid). CRASH-2 showed tranexamic acid (1 g over 10 min then 1 g over 8 h) given within 3 h of injury reduces death from bleeding. Factor VIIa has no mortality benefit in trauma.

**2.10 — D** (Occult hypoperfusion). Normal vital signs with raised lactate and base deficit indicate occult (compensated) hypoperfusion; it predicts MODS and mortality and requires further resuscitation and a search for bleeding or ischaemia.

CHAPTER 3

# Wound Healing and Tissue Repair

**Key points**

- Healing occurs by **regeneration** (same tissue, e.g. epithelium, liver, bone) or **repair** (fibrous scar).
- Four overlapping phases: **haemostasis → inflammation → proliferation → remodelling**.
- A healed wound never regains full strength: maximum ≈ **80% of normal tensile strength**.
- Most failures of healing are due to **infection, ischaemia, tension, foreign material and systemic disease**.

## 1. Phases of wound healing

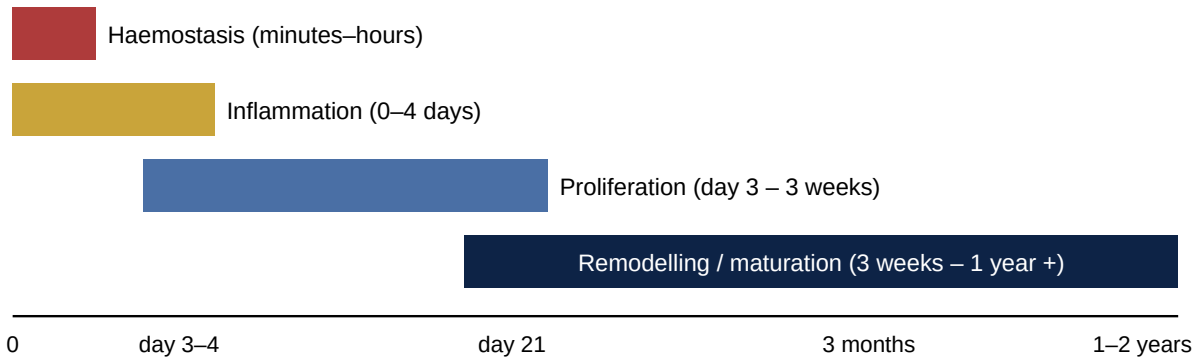



*Figure 3.1 — Overlapping phases of wound healing.*

| Phase | Key cells / events | Key mediators |
|---|---|---|
| Haemostasis | Vasoconstriction, platelet plug, fibrin clot (provisional matrix) | PDGF, TGF-β from platelets |
| Inflammation | **Neutrophils** (first 24–48 h, kill bacteria) → **macrophages** (day 2–3; the key cell that orchestrates repair) | IL-1, TNF-α, growth factors |
| Proliferation | **Fibroblasts** lay down **type III collagen**; angiogenesis → granulation tissue; epithelialisation; **myofibroblasts** cause contraction | FGF, VEGF, EGF, TGF-β |
| Remodelling | Type III replaced by **type I collagen**; cross-linking; scar becomes paler, flatter and stronger; vascularity falls | Matrix metalloproteinases |

**Exam pearl**

Collagen synthesis needs **vitamin C** (hydroxylation of proline and lysine), oxygen, iron and α-ketoglutarate. Zinc is needed for epithelialisation. Tensile strength: ~20% at 3 weeks, ~80% by 3 months onward.

## 2. Types of wound healing

| Type | Description | Example |
|---|---|---|
| **Primary intention** | Clean wound, edges apposed (sutures, staples, glue). Minimal granulation; fine scar. | Clean surgical incision |
| **Secondary intention** | Wound left open; fills with granulation tissue, contracts and epithelialises. Larger scar. | Drained abscess, pilonidal cavity |
| **Delayed primary (tertiary) closure** | Wound left open 3–5 days until contamination controlled, then sutured. | Contaminated traumatic wound, dirty laparotomy skin |

## 3. Factors impairing wound healing

### Local

- Infection
- Poor blood supply / ischaemia, smoking
- Haematoma, seroma, dead space
- Foreign body, necrotic tissue
- Tension, excessive movement
- Previous radiotherapy
- Poor surgical technique

### Systemic

- Old age
- Malnutrition, hypoproteinaemia; deficiency of vitamins A, C, zinc
- Diabetes mellitus
- Corticosteroids (vitamin A partly reverses), chemotherapy, immunosuppression
- Jaundice, uraemia
- Anaemia, hypoxia, shock
- Malignancy, connective tissue disorders (Ehlers–Danlos)

**Memory aid — "DIDN'T HEAL"**
**D**iabetes, **I**nfection, **D**rugs (steroids, chemo), **N**utrition, **T**issue necrosis/foreign body · **H**ypoxia/ischaemia, **E**xcess tension, **A**nother wound (competing demand), **L**ow temperature/radiation.

## 4. Abnormal scars

| Feature | Hypertrophic scar | Keloid |
|---|---|---|
| Boundary | Confined to the wound margins | **Extends beyond** original wound |
| Timing | Within weeks of injury | Months, may be delayed |
| Natural history | Often regresses spontaneously | Rarely regresses |
| Sites | Across flexures, tension lines | Earlobe, sternum, shoulder, deltoid |
| Population | Any | Dark-skinned, familial, age 10–30 |
| Excision | Improves if tension corrected | **High recurrence** after excision alone |
| Treatment | Pressure garments, silicone gel sheets, intralesional triamcinolone, (keloid) excision + steroid/radiotherapy | |

## 5. Wound classification and infection risk

| Class | Definition | Example | Approx. SSI risk* |
|---|---|---|---|
| Clean | No hollow viscus entered | Hernia repair, thyroidectomy | < 2% |
| Clean-contaminated | Viscus opened under controlled conditions | Elective cholecystectomy, colectomy | < 10% |
| Contaminated | Acute inflammation or gross spillage; fresh trauma | Non-purulent appendicitis, spillage | ~15–20% |
| Dirty | Pus, perforated viscus, old trauma | Faecal peritonitis, abscess | > 30% |

*Approximate figures for orientation; rates vary with patient and procedure.

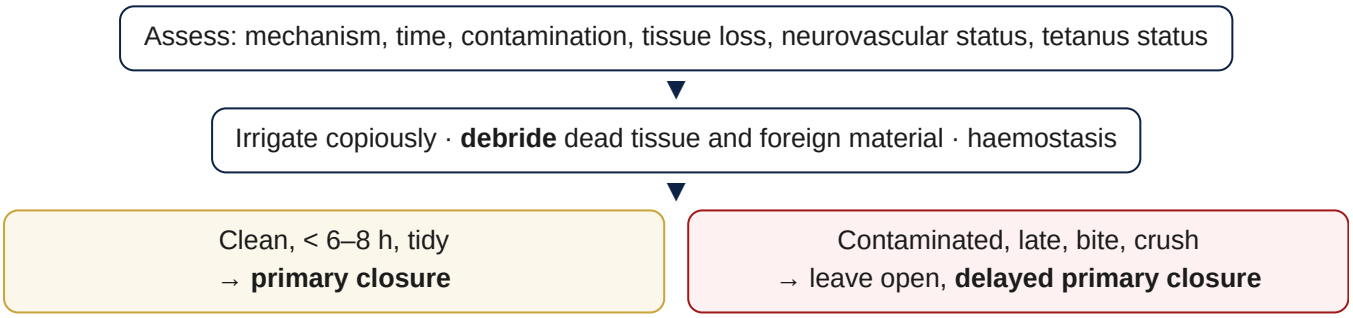
## 6. Healing in specialised tissues

| Tissue | Key facts |
|---|---|
| Bone | Haematoma → inflammation → soft callus → hard callus → remodelling. Primary (direct) healing with rigid fixation; secondary healing via callus. |
| Nerve | **Neurapraxia** (conduction block, full recovery), **axonotmesis** (axon divided, sheath intact — Wallerian degeneration, good recovery), **neurotmesis** (complete division — needs repair). Regrowth ≈ **1 mm/day**. |
| Tendon | Slow; early controlled mobilisation reduces adhesions. |
| Gut | Submucosa provides strength; anastomosis weakest at **day 3–5** (collagen lysis) — leaks typically present day 5–7. |

## 7. Chronic wounds and ulcers

| Ulcer | Typical site | Features |
|---|---|---|
| Venous | Gaiter area, medial malleolus | Shallow, sloping edge, lipodermatosclerosis, haemosiderin; treat with compression (if ABPI > 0.8) |
| Arterial | Toes, pressure points, shin | Punched-out, painful, cold pulseless foot |
| Neuropathic | Plantar MTP heads, heel | Painless, callus rim, diabetes |
| Pressure | Sacrum, heels, trochanters | Immobile patients; graded I–IV |
| **Marjolin's ulcer** | Chronic scar/ulcer, burns | **Squamous cell carcinoma** in chronic wound; everted edge, painless, slow — biopsy any non-healing ulcer |

## 8. Wound management essentials




**Suture removal (approx.):** face 3–5 days · scalp 7–10 · trunk/abdomen 10–14 · limbs 10–14 · back 14. **Negative-pressure wound therapy** promotes granulation and reduces oedema in open wounds.

## Chapter 3 — Self-assessment MCQs (one best answer)

Choose the single best answer. Options are listed alphabetically.

**3.1** A 50-year-old man had his laparotomy wound closed 10 days ago. A biopsy of the wound edge shows abundant fibroblasts, new capillaries and predominantly type III collagen. Which phase of healing is this?

A. Haemostasis
B. Inflammatory phase
C. Maturation phase
D. Proliferative phase
E. Remodelling phase

**3.2** Which cell is regarded as essential for coordinating normal wound healing, such that its depletion (unlike neutrophil depletion) significantly impairs repair?

A. Fibroblast
B. Lymphocyte
C. Macrophage
D. Mast cell
E. Neutrophil

**3.3** A 23-year-old woman develops a raised, itchy, firm scar on her earlobe 6 months after piercing. It extends well beyond the original puncture site. Simple excision is planned. What is the most important counselling point?

A. It is a premalignant lesion
B. It will regress spontaneously within a year
C. Pressure therapy is contraindicated
D. Radiotherapy is the first-line treatment
E. Recurrence is common after excision alone

**3.4** A 40-year-old man with a perforated appendix and generalised peritonitis undergoes laparotomy. The surgeon closes the fascia but leaves the skin open, planning closure on day 4. What is this method called?

A. Healing by first intention
B. Healing by second intention
C. Primary closure
D. Secondary suture
E. Tertiary (delayed primary) closure

**3.5** A 65-year-old man has a non-healing ulcer at the edge of a burn scar sustained 30 years ago. The ulcer has a raised, everted edge and has enlarged slowly. What is the most likely diagnosis?

A. Basal cell carcinoma
B. Keloid
C. Malignant melanoma
D. Pyoderma gangrenosum
E. Squamous cell carcinoma

**3.6** A 70-year-old man on long-term prednisolone for COPD has poor healing of his laparotomy wound. Which agent is known to partly reverse the effect of steroids on wound healing?

A. Vitamin A
B. Vitamin C
C. Vitamin D
D. Vitamin E
E. Zinc

**3.7** A 35-year-old man sustains a forearm laceration with complete division of the median nerve, which is repaired primarily 15 cm proximal to the thenar muscles. Approximately how long before reinnervation of the thenar muscles is expected?

A. 2 weeks
B. 6 weeks
C. 3 months
D. 5 months
E. 12 months

**3.8** Following an elective anterior resection, the colorectal anastomosis is at its weakest at which time, owing to collagenolysis exceeding synthesis?

A. Day 0–1
B. Day 3–5
C. Day 10–14
D. Week 3–4
E. Month 3

**3.9** A malnourished 55-year-old alcoholic man has poor wound healing, bleeding gums and perifollicular haemorrhages after a hernia repair. Which step of collagen synthesis is most affected?

A. Cleavage of procollagen peptides
B. Cross-linking by lysyl oxidase
C. Glycosylation of hydroxylysine
D. Hydroxylation of proline and lysine
E. Triple helix secretion by exocytosis

**3.10** A 30-year-old man presents 12 hours after a dog bite to the hand with a 3 cm ragged laceration. Tetanus status is up to date. What is the most appropriate wound management?

A. Clean, debride and close primarily without antibiotics
B. Clean, debride, leave open and give antibiotics
C. Primary closure with sutures and antibiotics
D. Primary closure with tissue adhesive
E. Skin grafting

## Answer key with explanations

**3.1 — D** (Proliferative phase). The proliferative phase (day 3 to ~3 weeks) is characterised by fibroblasts, angiogenesis (granulation tissue) and deposition of type III collagen. Remodelling (maturation) replaces it with type I collagen.

**3.2 — C** (Macrophage). Macrophages arrive by day 2–3, clear debris and secrete growth factors (PDGF, TGF-β, FGF, VEGF) that drive fibroblast proliferation and angiogenesis. Healing can proceed without neutrophils in a clean wound but not without macrophages.

**3.3 — E** (Recurrence is common after excision alone). A lesion extending beyond the wound margins is a keloid. Keloids rarely regress and recur frequently after simple excision; excision is combined with intralesional steroid, pressure or radiotherapy. Spontaneous regression is a feature of hypertrophic scars.

**3.4 — E** (Tertiary (delayed primary) closure). Leaving a contaminated wound open for 3–5 days and then suturing it before granulation tissue forms is delayed primary (tertiary) closure. Healing by secondary intention means the wound is left to granulate and contract without suturing.

**3.5 — E** (Squamous cell carcinoma). A Marjolin's ulcer is a squamous cell carcinoma arising in a chronic scar or ulcer, classically an old burn scar. An everted edge suggests SCC; BCC has a rolled, pearly edge and is rare in this setting.

**3.6 — A** (Vitamin A). Vitamin A counteracts the anti-inflammatory effect of corticosteroids on wound healing (stimulating the inflammatory phase). Vitamin C is needed for collagen hydroxylation but does not reverse steroid effects.

**3.7 — D** (5 months). Axonal regeneration proceeds at about 1 mm per day after a lag period: 150 mm ≈ 150 days ≈ 5 months.

**3.8 — B** (Day 3–5). In the early days after anastomosis, collagen breakdown exceeds synthesis, so the anastomosis relies mainly on sutures; strength is lowest around day 3–5, which explains why leaks often present around day 5–7.

**3.9 — D** (Hydroxylation of proline and lysine). Scurvy (vitamin C deficiency) impairs prolyl and lysyl hydroxylase, so stable collagen triple helices cannot form. Lysyl oxidase cross-linking requires copper and is a close but incorrect distractor.

**3.10 — B** (Clean, debride, leave open and give antibiotics). Bites to the hand presenting late are heavily contaminated (Pasteurella, anaerobes, staphylococci); they should be irrigated, debrided, left open (or closed later) and covered with co-amoxiclav. Primary closure risks deep infection.

CHAPTER 4

# Surgical Infection

**Key points**

- Infection follows when bacterial inoculum and virulence overcome host defences: **Infection risk ∝ (dose × virulence) / host resistance**.
- **Surgical site infection (SSI)** is the commonest healthcare-associated infection in surgical patients.
- Pus needs **drainage**; dead tissue needs **debridement**; antibiotics are adjuncts, not substitutes, for **source control**.
- Sepsis is time-critical: antibiotics within **1 hour** of recognition.

## 1. Surgical site infection (CDC definitions)

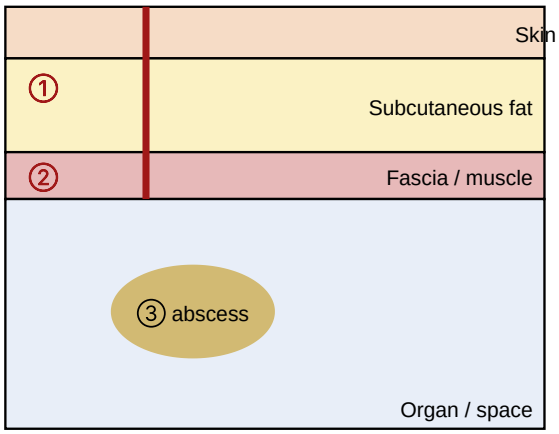



*Figure 4.1 — Levels of SSI: ① superficial incisional ② deep incisional ③ organ/space.*

| Type | Involves |
|---|---|
| Superficial incisional | Skin and subcutaneous tissue |
| Deep incisional | Fascia and muscle |
| Organ/space | Any organ or space opened (e.g. pelvic abscess) |

Occurs within **30 days** of surgery, or **90 days** if an implant is left in place.

**ASEPSIS** and **Southampton** scoring systems grade wound infection.

### Prevention of SSI (care bundle)

| Pre-operative | Intra-operative | Post-operative |
|---|---|---|
| Treat remote infection<br>Stop smoking, control glucose<br>Shower on day of surgery<br>Hair removal only if needed — **clippers**, not razors<br>MRSA screening/decolonisation | **Prophylactic antibiotic within 60 min before incision**; repeat if surgery > 4 h or blood loss > 1.5 L<br>Skin prep: **chlorhexidine–alcohol**<br>Maintain normothermia, oxygenation<br>Gentle tissue handling, minimal dead space | Sterile dressing for 48 h<br>Aseptic wound care<br>Glycaemic control<br>Prophylaxis usually single dose, ≤ 24 h |

## 2. Common surgical infections

| Infection | Organism(s) | Clinical features | Management |
|---|---|---|---|
| Cellulitis | Strep. pyogenes, Staph. aureus | Spreading erythema, warmth, ill-defined edge; lymphangitis | Elevation, flucloxacillin (± benzylpenicillin) |
| Erysipelas | Strep. pyogenes | Superficial, raised, **sharply demarcated** edge (face, leg) | Penicillin |
| Abscess | Staph. aureus (commonest) | Localised pus, fluctuation, "pyogenic membrane" | **Incision and drainage**; antibiotics only for cellulitis/systemic upset |
| **Necrotising fasciitis** | Type I polymicrobial; Type II Group A Strep | **Pain out of proportion**, rapid spread, dusky skin, bullae, crepitus, systemic toxicity; perineum = **Fournier's gangrene** | Resuscitate, broad-spectrum IV antibiotics (incl. clindamycin), **urgent radical debridement**, re-look at 24 h |
| **Gas gangrene** | *Clostridium perfringens* | Contaminated, ischaemic muscle wounds; severe pain, crepitus, "mousy" smell, bronze skin, toxaemia | Radical excision of dead muscle, high-dose penicillin + metronidazole/clindamycin, HBO if available |
| **Tetanus** | *Clostridium tetani* (tetanospasmin) | Trismus (lockjaw), risus sardonicus, opisthotonus, spasms, autonomic instability | Wound debridement, human tetanus immunoglobulin, metronidazole, sedation, ICU |
| Pseudomembranous colitis | *Clostridioides difficile* | Diarrhoea after antibiotics (clindamycin, cephalosporins, co-amoxiclav); toxic megacolon | Stop culprit, oral vancomycin or fidaxomicin, isolation |

### Tetanus prophylaxis after a wound

| Immunisation history | Clean minor wound | Tetanus-prone wound* |
|---|---|---|
| Unknown or < 3 doses | Vaccine | Vaccine **+ human tetanus immunoglobulin** |
| ≥ 3 doses | Vaccine only if > 10 years since last dose | Vaccine if > 5 years since last dose |

*Tetanus-prone: delay > 6 h, puncture, soil/manure contamination, devitalised tissue, compound fracture, burns, animal bites.

## 3. Sepsis and source control

**Suspect sepsis**: infection + new organ dysfunction (NEWS ≥ 5, confusion, hypotension, oliguria, ↑ lactate)

▼

**"Sepsis Six" within 1 hour**: Give $O_2$ · Take blood cultures · Give IV antibiotics · Give IV fluids · Measure lactate · Monitor urine output

▼

Imaging to locate source (US / CT)

▼

**Source control**: drain abscess (percutaneous or open), debride necrosis, remove infected device, resect/divert perforated bowel

> **Exam pearl**
> Persistent swinging pyrexia, leucocytosis and rising CRP 5–7 days after abdominal surgery = **intra-abdominal (e.g. pelvic or subphrenic) abscess** until proven otherwise → CT and drainage.

## 4. Antibiotic principles

- **Prophylaxis**: short course (usually a single dose) to reduce SSI — clean-contaminated and contaminated procedures, and clean surgery with implants.
- **Treatment**: empirical broad-spectrum first, then narrow according to culture; review at 48–72 h.
- Stewardship: avoid prolonged courses — drives resistance (MRSA, ESBL, CPE) and *C. difficile*.
- Anaerobic cover (metronidazole) for colorectal, appendix and gynaecological surgery.

## 5. Blood-borne viruses and the surgeon

| Virus | Risk of transmission after needlestick (source positive) | Post-exposure action |
|---|---|---|
| Hepatitis B | ~30% (if non-immune, HBeAg +) | Vaccinate staff; HBIG + booster if non-immune |
| Hepatitis C | ~3% | Follow-up testing; early treatment if seroconversion |
| HIV | ~0.3% | **PEP** ideally within 1 h (up to 72 h) for 28 days |

> **Memory aid — needlestick "Rule of 3s"**
> HBV **30%** · HCV **3%** · HIV **0.3%**. Immediately: encourage bleeding, wash with soap and water, report, test source with consent.

## Chapter 4 — Self-assessment MCQs (one best answer)

Choose the single best answer. Options are listed alphabetically.

**4.1** A 55-year-old diabetic man had an inguinal hernia repair with mesh. Ten weeks later he presents with a discharging sinus at the wound, with deep infection around the mesh. How should this infection be classified?

A. Deep incisional SSI
B. Not an SSI because it is beyond 30 days
C. Organ/space SSI
D. Stitch abscess
E. Superficial incisional SSI

**4.2** A 35-year-old woman is scheduled for elective laparoscopic cholecystectomy. Hair removal from the umbilicus is needed. Which method minimises the risk of surgical site infection?

A. Depilatory cream the night before
B. Electric clippers immediately before surgery
C. No hair removal under any circumstance
D. Razor shave immediately before surgery
E. Razor shave the night before

**4.3** A 48-year-old diabetic man has severe perineal pain, fever and scrotal swelling. The skin is dusky with crepitus, and pain is out of proportion to signs. BP 90/60 mmHg. After resuscitation and IV antibiotics, what is the most important next step?

A. CT scan of the pelvis before any intervention
B. Hyperbaric oxygen therapy
C. Incision and drainage under local anaesthesia
D. Intravenous immunoglobulin
E. Urgent radical surgical debridement

**4.4** A farmer has a deep, soil-contaminated wound to the thigh. Three days later he has severe pain, swelling, crepitus, a sweet 'mousy' odour and serosanguinous discharge with toxaemia. What is the most likely causative organism?

A. Bacteroides fragilis
B. Clostridium perfringens
C. Clostridium tetani
D. Staphylococcus aureus
E. Streptococcus pyogenes

**4.5** A 40-year-old labourer steps on a rusty nail in a cattle shed 10 hours ago. He received a full primary course of tetanus vaccination as a child, and his last booster was 7 years ago. What is the appropriate tetanus prophylaxis?

A. Human tetanus immunoglobulin only
B. Metronidazole only
C. No prophylaxis required
D. Tetanus toxoid booster only
E. Tetanus toxoid plus human tetanus immunoglobulin

**4.6** A 30-year-old man has a hot, fluctuant 4 cm swelling on the buttock for 5 days with minimal surrounding erythema. He is systemically well. What is the most appropriate treatment?

A. Aspiration and oral antibiotics
B. Incision and drainage
C. Incision and drainage plus a 2-week antibiotic course
D. Oral flucloxacillin for 7 days
E. Topical antibiotic and warm compresses

**4.7** Seven days after a laparotomy for perforated appendicitis, a 25-year-old man has swinging fever, tenesmus, mucous diarrhoea and a tender boggy mass on rectal examination. What is the most likely diagnosis?

A. Anastomotic leak
B. Clostridioides difficile colitis
C. Pelvic abscess
D. Subphrenic abscess
E. Urinary tract infection

**4.8** An elective open right hemicolectomy is expected to last 2 hours. When should prophylactic intravenous antibiotics be given for maximum effect?

A. At the end of the operation
B. At the time of skin closure
C. For 5 days post-operatively
D. On the evening before surgery
E. Within 60 minutes before skin incision

**4.9** A theatre nurse sustains a deep needlestick injury from a hollow needle used on a patient known to be HIV-positive with a detectable viral load. Which action is most appropriate?

A. Await the nurse's baseline HIV result before deciding
B. Hepatitis B immunoglobulin only
C. No action unless symptoms develop
D. Start HIV post-exposure prophylaxis as soon as possible
E. Test the nurse for HIV at 6 months only

**4.10** Five days after receiving co-amoxiclav for a wound infection, a 75-year-old woman develops profuse watery diarrhoea, abdominal pain, fever and a white cell count of 18 × $10^9$/L. Stool toxin is positive. What is the most appropriate first-line treatment?

A. Ciprofloxacin
B. Intravenous metronidazole alone
C. Loperamide
D. Oral vancomycin
E. Subtotal colectomy

## Answer key with explanations

**4.1 — A** (Deep incisional SSI). With an implant, an SSI can be defined up to 90 days. Infection involving the deep layers (mesh lies on the fascia/muscle) is a deep incisional SSI. Organ/space SSI involves an opened cavity such as the peritoneal cavity.

**4.2 — B** (Electric clippers immediately before surgery). Razors cause micro-abrasions that become colonised; if hair must be removed, clippers on the day of surgery are recommended. Depilatory creams are acceptable but can cause skin reactions; razor shaving the night before is the worst option.

**4.3 — E** (Urgent radical surgical debridement). Fournier's gangrene (perineal necrotising fasciitis) requires emergency radical debridement of all necrotic tissue, with planned re-look. Delay for imaging increases mortality; HBO and IVIG are adjuncts only.

**4.4 — B** (Clostridium perfringens). Gas gangrene (clostridial myonecrosis) follows contaminated ischaemic muscle injury: severe pain, crepitus, bronze skin and a characteristic odour with profound toxaemia. C. tetani causes spasms, not myonecrosis.

**4.5 — D** (Tetanus toxoid booster only). This is a tetanus-prone wound in a fully immunised patient whose last dose was more than 5 years ago, so a booster is indicated. Immunoglobulin is added only if immunisation is incomplete or unknown.

**4.6 — B** (Incision and drainage). A fluctuant abscess requires drainage. Antibiotics are added only for surrounding cellulitis, systemic features, immunosuppression or diabetes. Antibiotics alone fail to penetrate the pyogenic membrane.

**4.7 — C** (Pelvic abscess). Swinging pyrexia with rectal symptoms (tenesmus, mucus diarrhoea) and a boggy mass anteriorly on PR is a pelvic abscess. C. difficile causes diarrhoea but not a boggy pelvic mass; subphrenic abscess gives shoulder-tip pain and chest signs.

**4.8 — E** (Within 60 minutes before skin incision). Prophylactic antibiotics should achieve peak tissue levels at the time of incision, so they are given within 60 minutes before incision (usually at induction). Giving them at closure is too late; prolonged courses add no benefit.

**4.9 — D** (Start HIV post-exposure prophylaxis as soon as possible). After significant exposure to HIV, PEP should start as soon as possible, ideally within 1 hour and certainly within 72 hours, and continue for 28 days. Treatment should not be delayed for the recipient's baseline result.

**4.10 — D** (Oral vancomycin). For C. difficile infection, stop the culprit antibiotic and give oral vancomycin (or fidaxomicin). IV metronidazole alone is not first line; antimotility agents are contraindicated; colectomy is reserved for fulminant colitis or toxic megacolon.

CHAPTER 5

# Fluid, Electrolyte and Acid–Base Balance; Surgical Nutrition

**Key points**

- Total body water ≈ **60%** of body weight in men (~50–55% in women, less in elderly and obese).
- Prescribe IV fluids for one of three purposes: **resuscitation, routine maintenance, replacement/redistribution**.
- Over-infusion of salt and water is as harmful as under-infusion (oedema, ileus, anastomotic leak).
- If the gut works, use it: **enteral nutrition** is preferred over parenteral.

## 1. Body fluid compartments

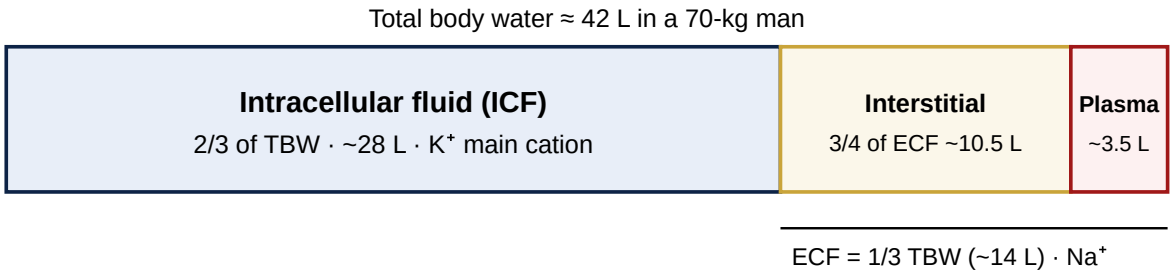



*Figure 5.1 — Distribution of total body water.*

Infused fluids distribute according to their content: **5% dextrose** spreads through all compartments (only ~1/12 stays intravascular); **isotonic crystalloid** distributes across the ECF (~1/4 intravascular); colloid and blood stay mainly intravascular initially.

## 2. Daily maintenance requirements (adult)

| Component | Requirement |
|---|---|
| Water | 25–30 mL/kg/day |
| Sodium, potassium, chloride | ~1 mmol/kg/day each |
| Glucose | 50–100 g/day (to limit starvation ketosis) |

Example (70 kg): ~2–2.1 L water, 70 mmol $Na^+$, 70 mmol $K^+$/day. Insensible loss ≈ 500–800 mL/day; ↑ ~ 10% per °C of fever.

## 3. Composition of common IV fluids (mmol/L)

| Fluid | $Na^+$ | $K^+$ | $Cl^-$ | Other | Notes |
|---|---|---|---|---|---|
| 0.9% sodium chloride | 154 | 0 | 154 | — | Excess → **hyperchloraemic metabolic acidosis** |
| Hartmann's (compound sodium lactate) | 131 | 5 | 111 | $Ca^{2+}$ 2, lactate 29 | "Balanced" crystalloid |
| Plasma-Lyte 148 | 140 | 5 | 98 | $Mg^{2+}$ 1.5, acetate, gluconate | Balanced |
| 5% dextrose | 0 | 0 | 0 | Glucose 50 g/L | Free water; risk of hyponatraemia |
| Dextrose 4% / saline 0.18% | 30 | 0 | 30 | Glucose 40 g/L | Maintenance; avoid in children |
| Plasma (reference) | 135–145 | 3.5–5 | 95–105 | $HCO_3^-$ 22–28 | — |

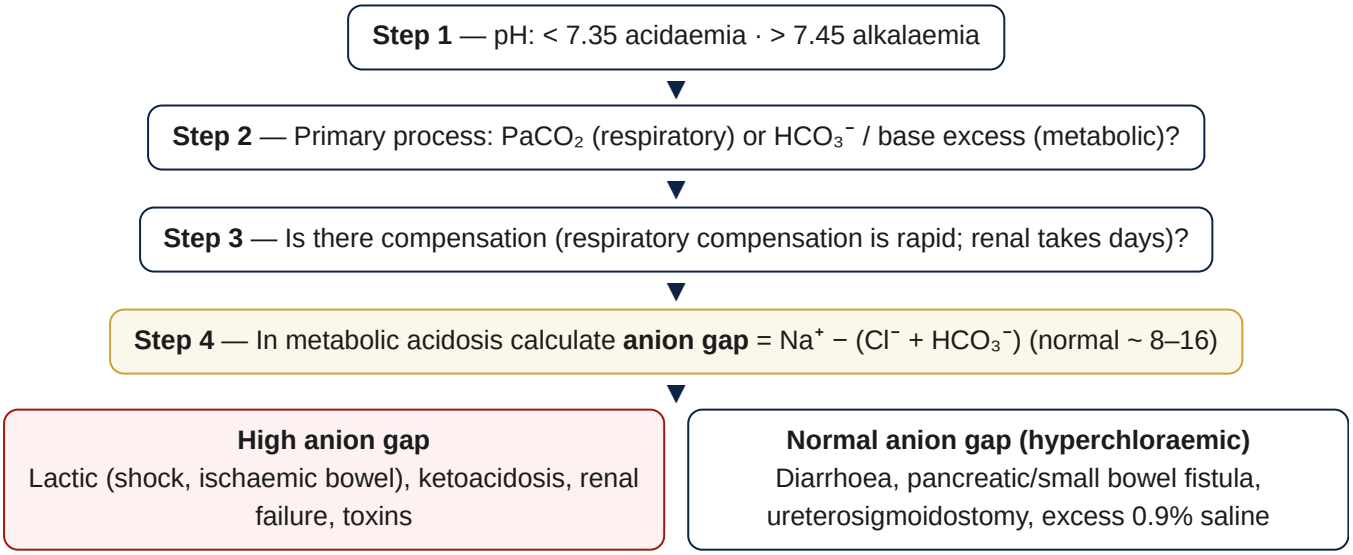
### Approximate composition of GI losses

| Fluid | Volume/day | Main electrolyte feature | Replace with |
|---|---|---|---|
| Gastric (vomiting, NG) | 1.5–2.5 L | High $H^+$ and $Cl^-$, moderate $K^+$ | 0.9% saline + KCl |
| Bile, pancreatic, small bowel | 3–4 L | $Na^+$ ~ plasma, **rich in $HCO_3^-$** | Balanced crystalloid (± bicarbonate) |
| Diarrhoea / ileostomy | Variable | $Na^+$, $K^+$, $HCO_3^-$ loss | Balanced crystalloid + KCl |

## 4. Electrolyte disorders — essentials

| Disorder | Surgical causes | Key points of management |
|---|---|---|
| **Hyponatraemia** | Excess hypotonic fluid (5% dextrose), SIADH (pain, opiates, lung/CNS disease), GI losses replaced with water, TURP syndrome | Assess volume status; fluid restriction (euvolaemic), saline (hypovolaemic). Correct slowly: **≤ 8–10 mmol/L in 24 h** → avoids **osmotic demyelination**. Hypertonic saline for seizures. |
| Hypernatraemia | Water deprivation, unreplaced insensible losses, diabetes insipidus | Replace free water slowly (cerebral oedema risk) |
| **Hypokalaemia** | Vomiting, NG aspirate, diarrhoea, fistula, villous adenoma, diuretics | Causes **ileus**, weakness, arrhythmia (U waves). IV KCl usually ≤ 10 mmol/h peripherally; never as a bolus. Check $Mg^{2+}$. |
| **Hyperkalaemia** | AKI, crush injury, rhabdomyolysis, massive transfusion, reperfusion, suxamethonium in burns | ECG: peaked T, wide QRS → VF. **10 mL 10% calcium gluconate** (stabilises myocardium) → **insulin 10 units + 50 mL 50% glucose** → salbutamol → treat cause / dialysis |
| Hypocalcaemia | Post-thyroidectomy/parathyroidectomy, pancreatitis, massive transfusion | Tingling, Chvostek's and Trousseau's signs; IV calcium gluconate |

## 5. Acid–base: a stepwise approach



| Disorder | Common surgical example |
|---|---|
| Metabolic acidosis | Shock, mesenteric ischaemia (lactate), high-output fistula |
| Metabolic alkalosis | **Gastric outlet obstruction / pyloric stenosis**: hypochloraemic, hypokalaemic alkalosis with **paradoxical aciduria** |
| Respiratory acidosis | Opioid over-sedation, post-op hypoventilation, flail chest |
| Respiratory alkalosis | Pain, anxiety, early sepsis, pulmonary embolism |

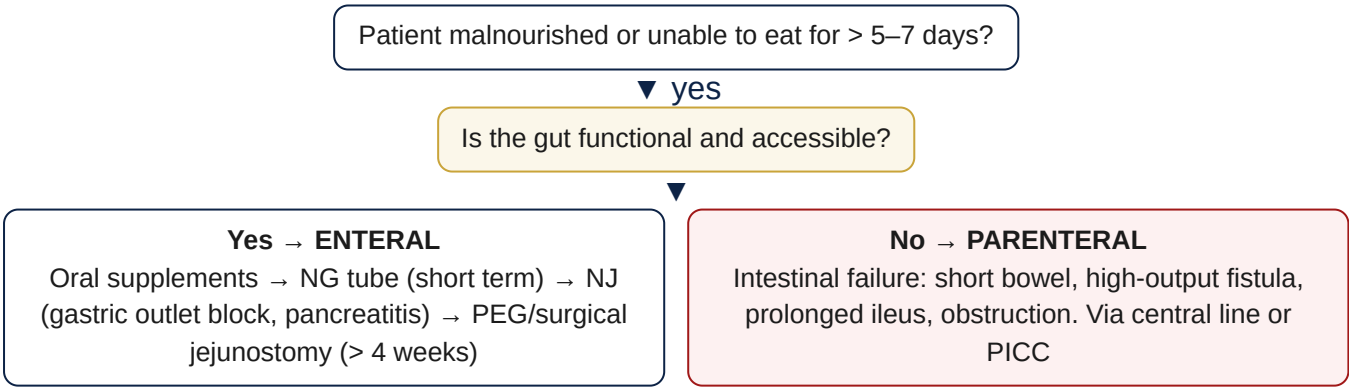
**Exam pearl — paradoxical aciduria**
In prolonged vomiting the kidney conserves $Na^+$ (aldosterone) by exchanging it for $K^+$ and then, as $K^+$ is depleted, for $H^+$ — so the urine becomes acidic despite systemic alkalosis. Treatment: **0.9% saline with added KCl**.

## 6. Surgical nutrition

### Assessment

- Screen all admissions (e.g. **MUST**): BMI, unintentional weight loss (> 10% in 3–6 months is significant), acute illness/no intake > 5 days.
- Requirements: energy **25–30 kcal/kg/day**, protein **1–1.5 g/kg/day** (1 g nitrogen = 6.25 g protein).
- Albumin reflects illness severity (acute-phase), not nutritional status alone.

### Choosing the route




| Enteral nutrition | Parenteral nutrition |
|---|---|
| Maintains gut barrier and mucosal integrity; cheaper; fewer infections<br>**Complications**: tube misplacement (check by pH/X-ray), aspiration, diarrhoea, blockage | Used only when gut cannot be used<br>**Complications**: catheter-related sepsis (commonest serious), thrombosis, pneumothorax at insertion, hyperglycaemia, liver dysfunction (cholestasis), electrolyte disturbance |

**Refeeding syndrome**

Starting feed in a starved patient → insulin surge drives **phosphate, potassium and magnesium** into cells → **hypophosphataemia** (hallmark), arrhythmias, heart failure, respiratory failure. High-risk: BMI < 16, weight loss > 15%, little intake > 10 days, alcoholism. Prevent: start at **~10 kcal/kg/day**, give **thiamine** before feeding, monitor and replace electrolytes.

## Chapter 5 — Self-assessment MCQs (one best answer)

Choose the single best answer. Options are listed alphabetically.

**5.1** A 60-year-old man has had 6 days of projectile vomiting from a gastric outlet obstruction due to a chronic duodenal ulcer. Which set of results is most likely?

A. Hyperchloraemic metabolic acidosis with hyperkalaemia
B. Hypochloraemic metabolic alkalosis with hypokalaemia and acidic urine
C. Hypochloraemic metabolic alkalosis with hypokalaemia and alkaline urine
D. Metabolic acidosis with a high anion gap
E. Respiratory alkalosis with hyponatraemia

**5.2** The patient in the previous scenario is dehydrated. Which intravenous fluid regimen is most appropriate for initial correction?

A. 0.9% sodium chloride with added potassium chloride
B. 5% dextrose alone
C. Dextrose 4%/saline 0.18%
D. Hartmann's solution alone
E. Sodium bicarbonate 8.4%

**5.3** A 72-year-old woman receives 3 L of 5% dextrose daily for 3 days after a hip operation. She becomes confused; serum sodium is 121 mmol/L. She is euvolaemic and not fitting. What is the most appropriate initial management?

A. Furosemide infusion
B. Hypertonic (3%) saline bolus
C. Rapid correction to 135 mmol/L within 24 h
D. Stop hypotonic fluids and restrict fluid intake
E. Tolvaptan

**5.4** A patient with acute kidney injury after a crush injury has serum potassium 7.1 mmol/L and peaked T waves with broadening QRS. What should be given first?

A. Calcium resonium orally
B. Insulin and glucose infusion
C. Intravenous 10% calcium gluconate
D. Nebulised salbutamol
E. Sodium bicarbonate infusion

**5.5** A 45-year-old man receives 6 L of 0.9% sodium chloride over 24 hours during resuscitation. Blood gas shows pH 7.29, $HCO_3^-$ 17 mmol/L, $Cl^-$ 118 mmol/L, $Na^+$ 141 mmol/L and normal lactate. What is the most likely acid–base disturbance?

A. High anion gap metabolic acidosis
B. Hyperchloraemic (normal anion gap) metabolic acidosis
C. Lactic acidosis
D. Metabolic alkalosis
E. Respiratory acidosis

**5.6** A 50-year-old man has a proximal jejunal fistula with an output of 2.5 L/day after laparotomy. He is losing weight and oral intake increases the fistula output. What is the most appropriate method of nutritional support?

A. Nasogastric tube feeding
B. Nasojejunal tube feeding
C. Oral nutritional supplements
D. Percutaneous endoscopic gastrostomy
E. Total parenteral nutrition

**5.7** A 38-year-old alcoholic man with a BMI of 15 and minimal intake for 3 weeks is started on full-strength nasogastric feeding. On day 2 he becomes weak, breathless and develops an arrhythmia. Which electrolyte abnormality is most characteristic?

A. Hypercalcaemia
B. Hyperkalaemia
C. Hypernatraemia
D. Hypomagnesaemia
E. Hypophosphataemia

**5.8** A 70-kg man is nil by mouth after an uncomplicated laparotomy with no abnormal losses. Which is the most appropriate daily maintenance prescription?

A. 1 L 0.9% saline with 20 mmol KCl
B. 2 L of 0.9% saline with no potassium
C. 2 L of 5% dextrose with no electrolytes
D. 4 L of Hartmann's solution
E. ~2 L water containing ~70 mmol $Na^+$, ~70 mmol $K^+$ and 50–100 g glucose

**5.9** Six days after a total gastrectomy a patient on parenteral nutrition via a central line develops rigors and fever spikes at the start of each infusion. There is no wound or chest focus. What is the most likely cause?

A. Anastomotic leak
B. Catheter-related bloodstream infection
C. Deep vein thrombosis
D. Fat overload syndrome
E. Refeeding syndrome

**5.10** A 55-year-old man has paralytic ileus 4 days after a right hemicolectomy with persistent nasogastric aspirates of 1.5 L/day. Which electrolyte abnormality most commonly perpetuates the ileus and must be corrected?

A. Hypercalcaemia
B. Hyperkalaemia
C. Hypermagnesaemia
D. Hypokalaemia
E. Hyponatraemia

## Answer key with explanations

**5.1 — B** (Hypochloraemic metabolic alkalosis with hypokalaemia and acidic urine). Loss of HCl causes hypochloraemic, hypokalaemic metabolic alkalosis; with prolonged vomiting the kidney exchanges $Na^+$ for $H^+$ ($K^+$ depleted), producing paradoxical aciduria. Alkaline urine occurs only early.

**5.2 — A** (0.9% sodium chloride with added potassium chloride). Chloride and potassium deficits drive the alkalosis; 0.9% saline supplies chloride, and potassium must be replaced. Hartmann's contains lactate (a bicarbonate precursor) and little chloride, so it is less suitable here.

**5.3 — D** (Stop hypotonic fluids and restrict fluid intake). Iatrogenic dilutional hyponatraemia in a euvolaemic patient without seizures is treated by stopping hypotonic fluid and restricting fluid, correcting no more than 8–10 mmol/L in 24 h. Hypertonic saline is reserved for severe symptoms such as seizures or coma.

**5.4 — C** (Intravenous 10% calcium gluconate). With ECG changes, IV calcium is given first to stabilise the myocardium; it does not lower potassium. Insulin–glucose then shifts $K^+$ into cells. Resonium acts too slowly for an emergency.

**5.5 — B** (Hyperchloraemic (normal anion gap) metabolic acidosis). Anion gap = 141 − (118 + 17) = 6, which is normal. Large volumes of 0.9% saline ($Cl^-$ 154 mmol/L) cause hyperchloraemic acidosis. Lactate is normal, excluding lactic acidosis.

**5.6 — E** (Total parenteral nutrition). A high-output proximal small-bowel fistula is a form of intestinal failure; feeding into the gut proximal to the fistula increases output and is not absorbed. PN is indicated until the fistula is controlled or repaired.

**5.7 — E** (Hypophosphataemia). Refeeding syndrome: insulin release drives phosphate, potassium and magnesium into cells; hypophosphataemia is the hallmark. Hypomagnesaemia also occurs and is a close distractor, but phosphate is the defining abnormality.

**5.8 — E** (~2 L water containing ~70 mmol $Na^+$, ~70 mmol $K^+$ and 50–100 g glucose). Maintenance is 25–30 mL/kg/day water with about 1 mmol/kg/day each of $Na^+$, $K^+$ and $Cl^-$ plus 50–100 g glucose. Saline alone overloads sodium and chloride; dextrose alone risks hyponatraemia and hypokalaemia.

**5.9 — B** (Catheter-related bloodstream infection). Line sepsis is the commonest serious complication of PN; rigors when the line is used are typical. Take paired line and peripheral cultures and remove the line if confirmed. An anastomotic leak is a close alternative but rigors linked to line use point to the catheter.

**5.10 — D** (Hypokalaemia). Potassium loss in gastric aspirate and urine is common after surgery, and hypokalaemia impairs smooth muscle function, prolonging ileus. Magnesium should also be checked, as hypomagnesaemia makes hypokalaemia resistant to correction.

CHAPTER 6

# Principles of Surgical Oncology

**Key points**

- Cancer results from accumulated **genetic mutations**: activation of oncogenes and loss of tumour suppressor genes.
- Management decisions are made by the **multidisciplinary team (MDT)** based on histology, stage and patient fitness.
- **Stage** (TNM) is the strongest predictor of prognosis and determines treatment intent.
- Surgery remains the main curative treatment for most solid tumours, often combined with (neo)adjuvant therapy.

## 1. Biology of cancer

| Concept | Key facts |
|---|---|
| Oncogenes | Gain-of-function, dominant (one allele): *RAS* (colorectal, pancreas), *HER2/ERBB2* (breast), *MYC*, *RET* (MEN 2) |
| Tumour suppressor genes | Loss-of-function, need **two hits** (Knudson): *TP53*, *APC* (FAP), *BRCA1/2*, *RB1* |
| DNA mismatch repair genes | *MLH1, MSH2, MSH6, PMS2* → **Lynch syndrome** (HNPCC); microsatellite instability |
| Hallmarks of cancer | Sustained proliferation, evading growth suppressors, resisting cell death, replicative immortality, angiogenesis, invasion & metastasis, reprogrammed metabolism, immune evasion |
| Carcinogens | Smoking (lung, bladder, oesophagus), UV (skin), asbestos (mesothelioma), aflatoxin (liver), aniline dyes (bladder), *H. pylori* (stomach), HPV (cervix, anus, oropharynx), HBV/HCV (liver) |

### Routes of spread

- **Local** invasion along tissue planes, nerves
- **Lymphatic**: typical of carcinomas
- **Haematogenous**: typical of sarcomas; liver (portal), lung, bone, brain
- **Transcoelomic**: peritoneum (ovary, stomach — Krukenberg tumour)
- **Implantation**: port sites, wound
- **Bone metastases** from "PB KTL": Prostate, Breast, Kidney, Thyroid, Lung

## 2. Grading and staging

**Grade** = degree of differentiation (well, moderately, poorly differentiated/G1–G3). **Stage** = anatomical extent of disease.

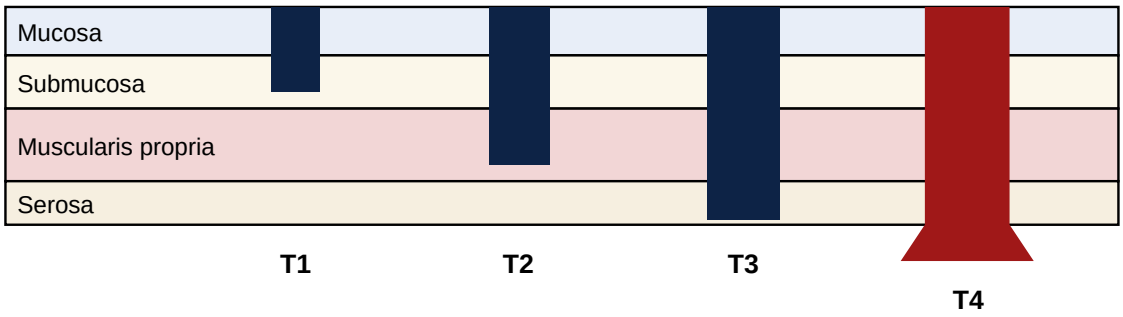



*Figure 6.1 — Principle of T staging in a hollow viscus (e.g. colon): depth of invasion through the bowel wall.*

| TNM | Meaning |
|---|---|
| **T** (Tumour) | Tis (in situ) → T1–T4 by size or depth of invasion |
| **N** (Nodes) | N0 = no regional nodes; N1–N3 = increasing nodal involvement |
| **M** (Metastasis) | M0 = none; M1 = distant metastasis |
| Prefixes | **c** = clinical; **p** = pathological; **y** = after neoadjuvant therapy (e.g. ypT2N0); **r** = recurrence |
| Resection margin | **R0** = clear microscopically; **R1** = microscopic tumour at margin; **R2** = macroscopic residual tumour |

## 3. Screening

Wilson and Jungner criteria — the condition should be an important health problem with a recognisable early stage; the test must be acceptable, safe, sensitive and specific; effective treatment must exist; and screening must be cost-effective.

| Programme | Test |
|---|---|
| Breast | Mammography (e.g. 3-yearly, age 50–70) |
| Bowel | Faecal immunochemical test (FIT) → colonoscopy |
| Cervix | HPV testing ± cytology |

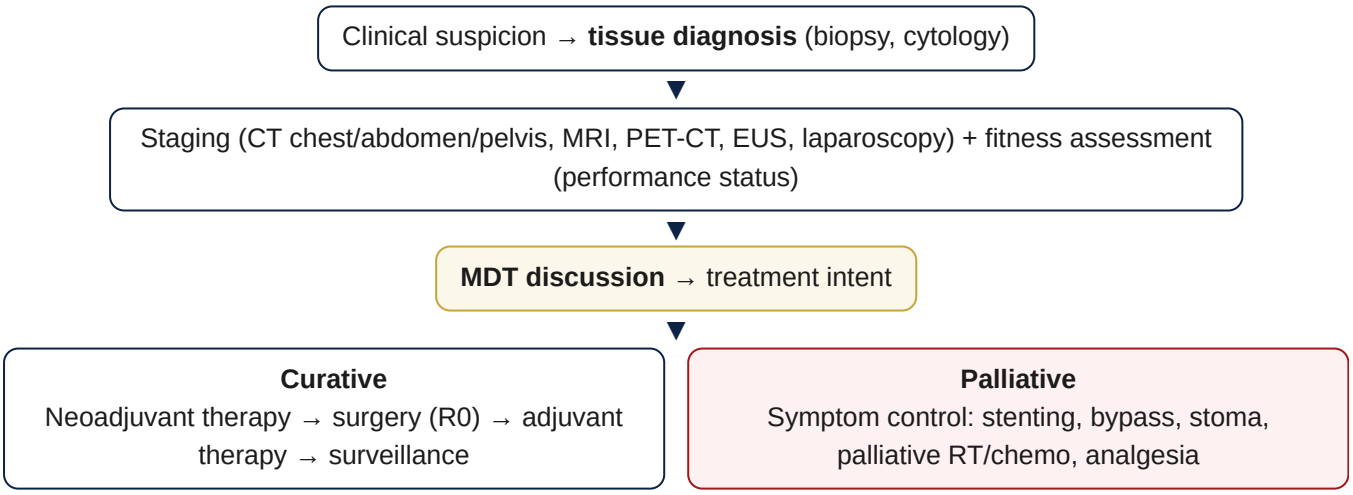
> **Exam pearl — screening biases**
> **Lead-time bias** (earlier diagnosis appears to prolong survival), **length-time bias** (screening detects slow-growing tumours), **overdiagnosis**.

## 4. Tumour markers

| Marker | Tumour | Main use |
|---|---|---|
| CEA | Colorectal | Monitoring for recurrence (not screening) |
| CA 19-9 | Pancreas, cholangiocarcinoma | Monitoring; ↑ in obstructive jaundice |
| AFP | Hepatocellular carcinoma, yolk-sac (non-seminomatous) germ cell tumours | Diagnosis and monitoring |
| β-hCG | Choriocarcinoma, germ cell tumours | Diagnosis and monitoring |
| CA 125 | Ovarian | Diagnosis (with US), monitoring |
| PSA | Prostate | Diagnosis, monitoring |
| Calcitonin | Medullary thyroid carcinoma | Diagnosis, follow-up |
| Thyroglobulin | Differentiated thyroid cancer | Follow-up after total thyroidectomy |

Most markers lack the sensitivity and specificity for population screening.

## 5. Principles of cancer treatment




| Role of surgery | Example |
|---|---|
| Diagnosis | Excision biopsy of lymph node |
| Staging | Sentinel node biopsy; staging laparoscopy (gastric cancer) |
| Curative resection | Wide excision with clear margins + en bloc nodal clearance |
| Prophylactic | Total colectomy in FAP; mastectomy in *BRCA* carriers; thyroidectomy in *RET* carriers |
| Palliation | Bypass for obstruction; defunctioning stoma |
| Metastasectomy | Resection of colorectal liver metastases |
| Reconstruction | Breast reconstruction |

| Term | Meaning |
|---|---|
| **Neoadjuvant** | Given **before** surgery to downstage the tumour and treat micrometastases (e.g. chemoradiotherapy for low rectal cancer) |
| **Adjuvant** | Given **after** resection to eradicate micrometastatic disease (e.g. chemotherapy for node-positive colon cancer) |
| Radiotherapy | Ionising radiation damages DNA; given in fractions to allow normal tissue repair |
| Targeted therapy | Trastuzumab (HER2), imatinib (GIST — *KIT*), cetuximab (*RAS* wild-type colorectal) |
| Hormonal | Tamoxifen, aromatase inhibitors (ER-positive breast); androgen deprivation (prostate) |
| Immunotherapy | Checkpoint inhibitors (PD-1, CTLA-4) in melanoma, MSI-high colorectal cancer |

### ECOG performance status

| 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Fully active | Restricted in strenuous activity, can do light work | Self-caring, up > 50% of day, cannot work | Limited self-care, in bed/chair > 50% | Completely disabled, bed-bound |

## 6. Inherited cancer syndromes

| Syndrome | Gene | Key cancers |
|---|---|---|
| Familial adenomatous polyposis | *APC* | Colorectal (~100% by 40 without colectomy), duodenal |
| Lynch syndrome | Mismatch repair genes | Right-sided colon, endometrium, ovary, urinary tract |
| Hereditary breast/ovary | *BRCA1/2* | Breast, ovary, prostate, pancreas |
| Li–Fraumeni | *TP53* | Sarcoma, breast, brain, adrenal, leukaemia |
| MEN 1 / MEN 2 | *MEN1* / *RET* | Parathyroid, pituitary, pancreas / medullary thyroid, phaeochromocytoma |

## Chapter 6 — Self-assessment MCQs (one best answer)

Choose the single best answer. Options are listed alphabetically.

**6.1** A 62-year-old man undergoes anterior resection after neoadjuvant chemoradiotherapy for rectal cancer. Histology shows tumour invading the muscularis propria with no nodal involvement. Which is the correct pathological staging notation?

A. cT2N0
B. pT2N0
C. rT2N0
D. ypT2N0
E. ypT3N0

**6.2** Histology after a right hemicolectomy shows tumour cells present at the inked circumferential resection margin under the microscope, with no residual disease visible to the naked eye. How is the resection classified?

A. N1
B. R0
C. R1
D. R2
E. Tis

**6.3** A 58-year-old man had a curative resection of a colon adenocarcinoma 18 months ago. Which tumour marker is most useful in follow-up to detect recurrence?

A. Alpha-fetoprotein
B. CA 125
C. CA 19-9
D. Carcinoembryonic antigen
E. Prostate-specific antigen

**6.4** A 24-year-old man has hundreds of colorectal adenomas on colonoscopy. His father died of colorectal cancer at 38. Which gene is most likely mutated?

A. APC
B. BRCA2
C. MLH1
D. RET
E. TP53

**6.5** A 45-year-old woman with a 2.5 cm ER-positive breast cancer and a positive sentinel node undergoes wide local excision and axillary treatment. Chemotherapy and endocrine therapy are given afterwards. What is the term for this post-operative treatment?

A. Adjuvant therapy
B. Induction therapy
C. Neoadjuvant therapy
D. Palliative therapy
E. Salvage therapy

**6.6** A study reports that patients with lung cancer detected by CT screening survive 2 years longer after diagnosis than those diagnosed with symptoms, yet the age at death is unchanged in both groups. Which bias best explains this?

A. Lead-time bias
B. Length-time bias
C. Observer bias
D. Overdiagnosis bias
E. Selection bias

**6.7** A 70-year-old man with metastatic gastric cancer can care for himself but is unable to work and spends about 40% of the day resting. What is his ECOG performance status?

A. 0
B. 1
C. 2
D. 3
E. 4

**6.8** A 35-year-old woman with a strong family history of breast and ovarian cancer is found to carry a pathogenic BRCA1 mutation. She has no cancer. She requests surgery to reduce her risk. What is the role of surgery here?

A. Curative
B. Diagnostic
C. Palliative
D. Prophylactic
E. Staging

**6.9** A 60-year-old man has a 12 cm high-grade soft-tissue sarcoma of the thigh. Staging is required to detect the most common site of distant spread. Which investigation is most appropriate?

A. Bone scan
B. CT of the chest
C. Liver ultrasound
D. MRI of the brain
E. Ultrasound of the inguinal nodes

**6.10** A 66-year-old man presents with a gastrointestinal stromal tumour (GIST) of the stomach that is unresectable at diagnosis. Which systemic agent targets the molecular driver of this tumour?

A. Bevacizumab
B. Cetuximab
C. Imatinib
D. Tamoxifen
E. Trastuzumab

## Answer key with explanations

**6.1 — D** (ypT2N0). The prefix 'y' indicates staging after neoadjuvant therapy and 'p' indicates pathological staging. Invasion into (not through) the muscularis propria is T2. ypT3 would mean invasion through the muscularis propria.

**6.2 — C** (R1). R1 = microscopic tumour at the margin; R0 = microscopically clear margins; R2 = macroscopic residual tumour. R1 resection carries a higher risk of local recurrence.

**6.3 — D** (Carcinoembryonic antigen). Serial CEA is used to detect recurrence after resection of colorectal cancer, together with surveillance CT. CA 19-9 is used mainly in pancreatic and biliary cancer; neither is suitable for screening.

**6.4 — A** (APC). Hundreds to thousands of adenomas in a young patient = familial adenomatous polyposis due to germline APC mutation (autosomal dominant); prophylactic colectomy is advised. Lynch syndrome (MLH1) causes cancer with few polyps.

**6.5 — A** (Adjuvant therapy). Treatment given after potentially curative surgery to eradicate micrometastatic disease is adjuvant therapy. Neoadjuvant therapy is given before surgery to downstage the tumour.

**6.6 — A** (Lead-time bias). Lead-time bias: screening advances the time of diagnosis, so survival from diagnosis appears longer even though death occurs at the same time. Length-time bias refers to preferential detection of slow-growing tumours.

**6.7 — C** (2). ECOG 2: ambulatory and capable of all self-care but unable to work; up and about more than 50% of waking hours. ECOG 3 = confined to bed or chair more than 50% of waking hours.

**6.8 — D** (Prophylactic). Risk-reducing mastectomy and salpingo-oophorectomy in BRCA carriers is prophylactic surgery, analogous to colectomy in FAP and thyroidectomy in RET carriers.

**6.9 — B** (CT of the chest). Sarcomas spread mainly by the bloodstream, most commonly to the lungs, so CT chest is the key staging investigation. Lymphatic spread is uncommon in most sarcomas, unlike carcinomas.

**6.10 — C** (Imatinib). Most GISTs harbour activating KIT (or PDGFRA) mutations and respond to the tyrosine kinase inhibitor imatinib, which may downstage tumours for resection. Trastuzumab targets HER2; cetuximab targets EGFR.

CHAPTER 7

# Pre-operative Assessment and Preparation

**Key points**

- Aims: confirm the indication, identify and **optimise** comorbidity, estimate risk, plan anaesthesia and post-operative care, and obtain **informed consent**.
- Investigations should be **targeted** to the patient and the operation, not routine.
- **Functional capacity** (≥ 4 METs) is a simple, powerful predictor of peri-operative risk.
- Most medications are continued; key exceptions are anticoagulants, antiplatelets, some diabetic drugs and the OCP/HRT.

## 1. ASA physical status classification

| ASA | Definition | Example |
|---|---|---|
| I | Normal healthy patient | Fit non-smoker |
| II | Mild systemic disease | Controlled hypertension, smoker, BMI 30–40, pregnancy |
| III | Severe systemic disease | Poorly controlled diabetes, COPD, BMI ≥ 40, stable angina, dialysis |
| IV | Severe systemic disease that is a constant threat to life | Recent MI (< 3 months), severe valve disease, sepsis |
| V | Moribund, not expected to survive without the operation | Ruptured AAA |
| VI | Brain-dead organ donor | — |

Suffix **"E"** = emergency surgery (e.g. ASA IIIE).

## 2. Structured pre-operative assessment

**History**: presenting problem, comorbidity, previous anaesthetics (PONV, difficult airway, suxamethonium apnoea, malignant hyperthermia in family), drugs, allergies, smoking/alcohol, functional capacity

▼

**Examination**: cardiorespiratory, airway (Mallampati, mouth opening, neck movement), BMI, site of surgery

▼

**Targeted investigations** + risk scoring (ASA, RCRI, frailty, P-POSSUM/NELA)

▼

**Optimise**: treat anaemia, control BP/glucose, stop smoking, prehabilitation, chest physiotherapy, nutrition

▼

**Plan**: consent, VTE prophylaxis, medication instructions, fasting, level of post-op care (ward/HDU/ICU)

## 3. Cardiac and respiratory risk

### Revised Cardiac Risk Index (Lee)

- High-risk surgery (intraperitoneal, intrathoracic, suprainguinal vascular)
- Ischaemic heart disease
- Heart failure
- Cerebrovascular disease
- Insulin-treated diabetes
- Creatinine > 177 µmol/L

Risk rises with each factor present.

### Functional capacity

**< 4 METs** (unable to climb two flights of stairs or walk briskly up a hill) = poor functional capacity → higher risk; consider **cardiopulmonary exercise testing (CPET)**: anaerobic threshold < 11 mL/kg/min indicates high risk.

### Elective surgery after MI

Defer elective non-cardiac surgery for at least **60 days (ideally 3–6 months)** after myocardial infarction.

## 4. Investigations (guided by age, ASA and grade of surgery)

| Test | Typical indication |
|---|---|
| Full blood count | Major surgery, anaemia suspected, expected blood loss |
| Urea & electrolytes | Renal disease, diuretics/ACE inhibitors, diabetes, major surgery |
| Coagulation screen | Anticoagulants, liver disease, bleeding history |
| ECG | Cardiovascular, renal or diabetic disease; older patients for major surgery |
| Chest X-ray | Not routine — only new/severe cardiorespiratory symptoms or signs |
| Echocardiogram | Murmur with symptoms, suspected heart failure |
| HbA1c | Diabetics (> 69 mmol/mol ≈ 8.5% → optimise before elective surgery) |
| Pregnancy test | Women of child-bearing age (with consent) |
| Sickle cell test | At-risk ethnic groups if status unknown |

## 5. Peri-operative management of medications

| Drug | Usual advice |
|---|---|
| Antihypertensives, β-blockers, statins | **Continue** (do not start β-blockers just before surgery). Some units omit ACE inhibitors/ARBs on the morning of surgery. |
| Aspirin | Usually continue (especially with coronary stents); stop 7 days only if bleeding risk critical (neurosurgery, prostate) |
| Clopidogrel / prasugrel / ticagrelor | Stop **5–7 days** before — **but never stop** dual antiplatelet therapy after recent coronary stent without cardiology advice |
| Warfarin | Stop **5 days** before; check INR < 1.5 day before; **bridge with LMWH** if high thrombotic risk (mechanical mitral valve, recent VTE) |
| DOACs (rivaroxaban, apixaban) | Stop 24–48 h before (longer if renal impairment); no bridging needed |
| Metformin / SGLT2 inhibitors | Omit on day of surgery (SGLT2 inhibitors from day before — euglycaemic DKA) |
| Insulin | Reduce long-acting dose; **variable-rate IV insulin infusion** if > 1 missed meal or poor control; first on list |
| Long-term corticosteroids | Continue + **peri-operative IV hydrocortisone** cover (risk of adrenal crisis) |
| Combined OCP / HRT | Stop OCP **4 weeks** before major/limb surgery (VTE risk) |
| MAOIs, lithium | Specialist advice (drug interactions) |

## 6. Fasting guidelines (elective adult)

**"6 – 4 – 2" rule**
**6 h** solid food (and milk) · **4 h** breast milk (infants) · **2 h** clear fluids (water, black tea/coffee, carbohydrate drinks).

## 7. Informed consent

- Valid consent needs: **capacity**, adequate **information**, and **voluntariness**.
- Capacity: understand, retain, weigh up the information and communicate a decision.
- Disclose **material risks** — those a reasonable patient would want to know, or that this particular patient would attach significance to (**Montgomery** principle) — and reasonable alternatives, including no treatment.
- Consent should be taken by the operating surgeon or someone capable of performing the procedure.
- Emergency with no capacity: act in the patient's **best interests**; respect valid advance refusals (e.g. Jehovah's Witness refusing blood).

## 8. Special risk groups

| Condition | Pre-operative concern |
|---|---|
| Diabetes | Hypo/hyperglycaemia, infection, silent ischaemia, renal disease; first on list |
| Jaundice | Coagulopathy (give vitamin K), **hepatorenal syndrome** (keep well hydrated, monitor urine output), sepsis, poor healing |
| Obesity | Difficult airway, OSA, VTE, wound infection |
| Chronic kidney disease | Hyperkalaemia, fluid balance, drug dosing, platelet dysfunction |
| Elderly / frail | Delirium, falls, reduced reserve; comprehensive geriatric assessment |
| Sickle cell disease | Avoid hypoxia, dehydration, hypothermia and acidosis (sickle crisis) |

**Exam pearl — VTE risk assessment**
Every admission needs VTE risk assessment. Prophylaxis: mechanical (graduated stockings, intermittent pneumatic compression) ± pharmacological (LMWH) — extended 28 days after major abdominal/pelvic cancer surgery.

## Chapter 7 — Self-assessment MCQs (one best answer)

Choose the single best answer. Options are listed alphabetically.

**7.1** A 54-year-old man with type 2 diabetes on insulin, with HbA1c 75 mmol/mol and stable angina, is listed for elective hernia repair. He is limited by angina after one flight of stairs. What is his ASA grade?

A. ASA I
B. ASA II
C. ASA III
D. ASA IV
E. ASA V

**7.2** A 68-year-old woman with atrial fibrillation ($CHA_2DS_2$-VASc 3) takes warfarin, INR 2.6. She is to undergo elective cholecystectomy. What is the most appropriate warfarin plan?

A. Continue warfarin and operate
B. Give prothrombin complex concentrate on the morning of surgery
C. Stop warfarin 2 days before surgery
D. Stop warfarin 5 days before and check INR the day before
E. Switch to aspirin 2 weeks before surgery

**7.3** A 60-year-old man had a drug-eluting coronary stent inserted 2 months ago and is on aspirin and clopidogrel. He is referred for an elective inguinal hernia repair. What is the best course of action?

A. Continue aspirin, stop clopidogrel 7 days before
B. Defer elective surgery until dual antiplatelet therapy can safely be stopped
C. Operate under regional anaesthesia without stopping either drug
D. Stop both drugs 7 days before surgery
E. Switch clopidogrel to LMWH bridging

**7.4** A 45-year-old woman taking prednisolone 15 mg daily for 2 years for rheumatoid arthritis is undergoing elective laparotomy. Which peri-operative measure is most important?

A. Double the oral prednisolone dose for 1 week before surgery
B. Give intravenous hydrocortisone at induction and post-operatively
C. Give no additional steroid
D. Stop prednisolone 1 week before surgery
E. Switch to dexamethasone

**7.5** A 32-year-old woman taking the combined oral contraceptive pill is listed for elective total knee replacement. What advice should she be given regarding her pill?

A. Continue the pill and use LMWH
B. No change is needed
C. Stop the pill 1 week before surgery
D. Stop the pill 4 weeks before surgery and use alternative contraception
E. Switch to hormone replacement therapy

**7.6** A healthy 30-year-old man is scheduled for an elective morning laparoscopic cholecystectomy. Until when may he drink water on the morning of surgery?

A. Midnight before surgery
B. Up to 1 hour before anaesthesia
C. Up to 2 hours before anaesthesia
D. Up to 4 hours before anaesthesia
E. Up to 6 hours before anaesthesia

**7.7** A 70-year-old man with obstructive jaundice from a pancreatic head tumour has prothrombin time 19 s (control 12 s). He is to undergo surgery. Which pre-operative measures are most important?

A. Fresh frozen plasma and fluid restriction
B. Intravenous vitamin K and adequate hydration with urine output monitoring
C. Oral vitamin K and diuretics
D. Platelet transfusion and mannitol
E. Tranexamic acid and fluid restriction

**7.8** A 72-year-old man is scheduled for elective open aortic aneurysm repair. He reports being unable to climb two flights of stairs because of breathlessness. Which investigation best objectively quantifies his peri-operative risk?

A. Cardiopulmonary exercise testing
B. Chest X-ray
C. Coronary angiography
D. Pulmonary function tests (spirometry)
E. Resting ECG

**7.9** A 40-year-old woman is consented for laparoscopic cholecystectomy. She is a professional singer. The surgeon does not mention the small risk of vocal cord injury from intubation, which later occurs. According to the Montgomery principle, the risk should have been disclosed because:

A. All risks above 1% must be disclosed
B. It is a risk this patient would likely attach significance to
C. Only the anaesthetist is responsible for airway risks
D. Risk disclosure depends on what a responsible body of doctors would disclose
E. The risk is common

**7.10** A 60-year-old man with type 2 diabetes on metformin and gliclazide, HbA1c 58 mmol/mol, is listed for an afternoon inguinal hernia repair, missing one meal. What is the most appropriate plan?

A. Continue all medications as normal
B. Omit gliclazide on the morning of surgery and monitor capillary glucose
C. Postpone surgery until HbA1c is below 48 mmol/mol
D. Start a variable-rate IV insulin infusion from the night before
E. Stop metformin 1 week before surgery

## Answer key with explanations

**7.1 — C** (ASA III). Poorly controlled diabetes and stable angina limiting activity are severe systemic diseases, i.e. ASA III. ASA IV requires disease that is a constant threat to life (e.g. recent MI, unstable angina).

**7.2 — D** (Stop warfarin 5 days before and check INR the day before). Warfarin is stopped 5 days pre-operatively and INR checked (< 1.5) the day before. Bridging is reserved for high thrombotic risk (e.g. mechanical mitral valve, VTE < 3 months); routine AF usually does not require it. PCC is for emergency reversal.

**7.3 — B** (Defer elective surgery until dual antiplatelet therapy can safely be stopped). Stopping dual antiplatelet therapy early after a coronary stent risks catastrophic stent thrombosis. Non-urgent surgery should be deferred (usually ≥ 6 months for DES) after cardiology advice. LMWH does not protect against stent thrombosis.

**7.4 — B** (Give intravenous hydrocortisone at induction and post-operatively). Long-term steroids suppress the HPA axis; patients cannot mount a stress cortisol response. IV hydrocortisone cover at induction and for 24–72 h after major surgery prevents adrenal crisis. Stopping steroids is dangerous.

**7.5 — D** (Stop the pill 4 weeks before surgery and use alternative contraception). The combined OCP increases VTE risk; it should be stopped 4 weeks before major or lower-limb surgery, with alternative contraception. If not stopped, thromboprophylaxis is essential.

**7.6 — C** (Up to 2 hours before anaesthesia). Clear fluids are allowed up to 2 hours before induction; solids/milk up to 6 hours. Prolonged fasting from midnight is unnecessary and worsens dehydration and insulin resistance.

**7.7 — B** (Intravenous vitamin K and adequate hydration with urine output monitoring). Obstructive jaundice prevents absorption of fat-soluble vitamin K (oral form is poorly absorbed), so give it IV. Jaundiced patients are prone to hepatorenal failure: ensure good hydration and monitor urine output. Fluid restriction is harmful.

**7.8 — A** (Cardiopulmonary exercise testing). Poor functional capacity (< 4 METs) before major surgery warrants CPET, which measures anaerobic threshold and peak $VO_2$ to stratify risk. Spirometry assesses lung function but not integrated cardiopulmonary reserve.

**7.9 — B** (It is a risk this patient would likely attach significance to). Montgomery replaced the Bolam standard for consent: a material risk is one a reasonable person in the patient's position would consider significant, or one the doctor knows (or should know) this patient would consider significant. The 'responsible body of doctors' test is the old Bolam approach.

**7.10 — B** (Omit gliclazide on the morning of surgery and monitor capillary glucose). With reasonable control and only one missed meal, sulphonylureas are omitted on the day (hypoglycaemia risk) with glucose monitoring; metformin is omitted at the missed meal. A VRIII is needed for longer fasting or poor control. HbA1c < 69 mmol/mol is acceptable.

CHAPTER 8

# Anaesthesia and Pain Relief

**Key points**

- General anaesthesia (GA) = the **triad** of hypnosis (unconsciousness), analgesia and muscle relaxation.
- Local and regional techniques avoid GA, block the stress response and provide excellent post-operative analgesia.
- Every surgeon must know **maximum safe doses of local anaesthetic** and how to recognise and treat toxicity.
- Pain control is **multimodal**: combine drugs with different mechanisms to reduce opioid use.

## 1. General anaesthesia

| Phase | Key points |
|---|---|
| Induction | IV agent (propofol, thiopental, ketamine, etomidate) or inhalational (sevoflurane — children) |
| Airway | Face mask, supraglottic airway (LMA), or **tracheal tube** (protects against aspiration) |
| Maintenance | Volatile agent (sevoflurane, desflurane) or total IV anaesthesia (propofol infusion — less PONV) |
| Muscle relaxation | Depolarising (**suxamethonium** — rapid onset) or non-depolarising (rocuronium, atracurium); reversal with neostigmine or sugammadex (rocuronium) |
| Emergence | Reverse relaxant, extubate when awake with protective reflexes |

### Rapid sequence induction (RSI)

For patients at risk of aspiration (emergency surgery, bowel obstruction, full stomach, pregnancy): **pre-oxygenation** → induction agent + rapid-onset relaxant (suxamethonium or high-dose rocuronium) → **cricoid pressure** → intubation with cuffed tube, no bag-mask ventilation.

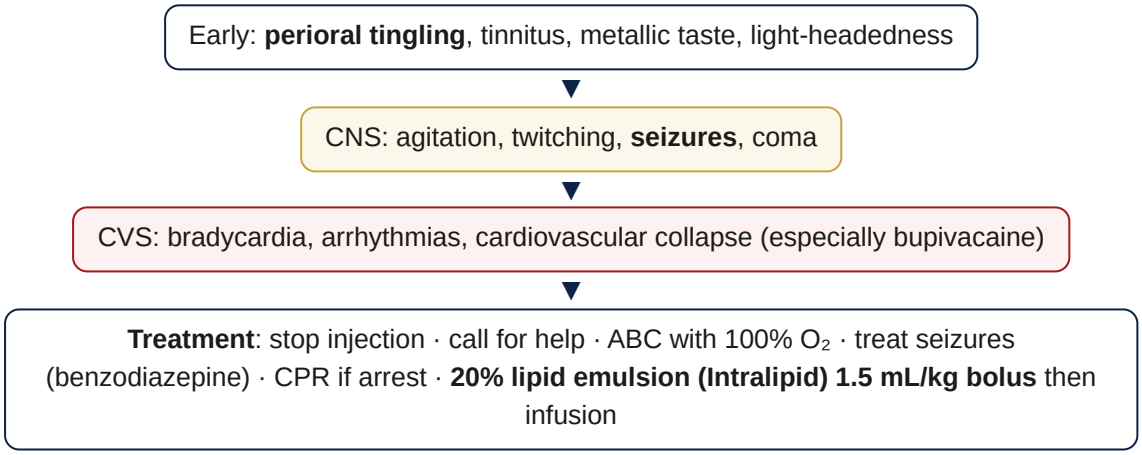
**Exam pearl — anaesthetic emergencies**
**Malignant hyperthermia**: autosomal dominant (*RYR1*), triggered by volatile agents and suxamethonium → rising end-tidal $CO_2$, tachycardia, rigidity, hyperthermia, hyperkalaemia → stop trigger, cool, **dantrolene**.
**Suxamethonium apnoea**: deficiency of plasma (pseudo)cholinesterase → prolonged paralysis → ventilate and sedate until it wears off.
**Suxamethonium hyperkalaemia**: avoid in burns, crush, denervation > 24–48 h after injury.

## 2. Local anaesthetics

| Agent | Max dose plain | Max dose with adrenaline | Onset / duration |
|---|---|---|---|
| Lidocaine (lignocaine) | **3 mg/kg** | **7 mg/kg** | Fast / 1–2 h |
| Bupivacaine / levobupivacaine | **2 mg/kg** | 2 mg/kg (2.5 mg/kg some guidance) | Slow / 4–8 h; most cardiotoxic |
| Prilocaine | 6 mg/kg | 8 mg/kg | Used for IV regional (Bier's) block; methaemoglobinaemia |

**Quick calculation**
1% solution = 10 mg/mL · 2% = 20 mg/mL · 0.5% = 5 mg/mL.
Example: 70 kg, plain lidocaine 3 mg/kg = 210 mg = **21 mL of 1%** (or 10.5 mL of 2%).

### Local anaesthetic systemic toxicity (LAST)




Adrenaline prolongs action and reduces bleeding; traditional teaching is to avoid it in end-artery territories (digits, penis, pinna).

## 3. Spinal versus epidural anaesthesia

| Feature | Spinal (subarachnoid) | Epidural |
|---|---|---|
| Space | Subarachnoid — into CSF, below L1/L2 (cord ends) | Epidural space — outside dura, any level |
| Dose / volume | Small (2–3 mL) | Large, via catheter |
| Onset | Rapid (minutes), dense block | Slower, segmental |
| Duration | Single shot, 2–3 h | Prolonged via catheter (post-op analgesia) |
| Main complications | Hypotension, **post-dural puncture headache** (postural; treat with fluids, caffeine, epidural blood patch), urinary retention, high/total spinal | Hypotension, accidental dural puncture, **epidural haematoma/abscess** (cord compression → urgent MRI and decompression), failed block |

**Contraindications** to neuraxial block: patient refusal, coagulopathy/anticoagulation, local infection, raised intracranial pressure, uncorrected hypovolaemia, fixed cardiac output (severe aortic stenosis — relative).

## 4. Post-operative pain management

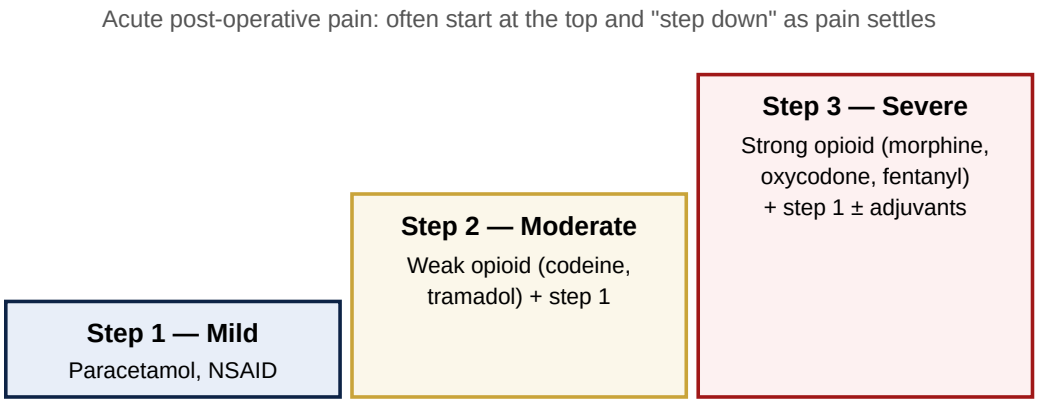



*Figure 8.1 — WHO analgesic ladder (line diagram).*

| Modality | Notes |
|---|---|
| Paracetamol | Foundation of multimodal analgesia; max 4 g/day (reduce if < 50 kg or liver disease) |
| NSAIDs | Opioid-sparing; avoid in renal impairment, peptic ulcer, asthma (sensitive), anastomotic concerns, elderly |
| Opioids | Side effects: **respiratory depression**, sedation, nausea/vomiting, constipation, ileus, itch, urinary retention. Reverse with **naloxone** 100–400 µg IV titrated |
| PCA (patient-controlled analgesia) | Small bolus (e.g. morphine 1 mg), lockout ~5 min; safety because a sedated patient stops pressing |
| Regional techniques | Epidural, wound catheters, TAP block, nerve blocks |
| Adjuvants | Gabapentinoids, ketamine, lidocaine infusion, dexamethasone |

**Why treat pain?**
Uncontrolled pain → reduced coughing/deep breathing (atelectasis, pneumonia), immobility (DVT), tachycardia/myocardial ischaemia, stress response, delirium, and chronic post-surgical pain.

**Assessment**: numerical rating scale (0–10), verbal rating scale, visual analogue scale; assess at rest and on movement/coughing; observational scales in dementia and children.

## Chapter 8 — Self-assessment MCQs (one best answer)

Choose the single best answer. Options are listed alphabetically.

**8.1** A 60-kg woman requires excision of a large lipoma under local anaesthesia using 1% lidocaine without adrenaline. What is the maximum volume that can safely be used?

A. 9 mL
B. 18 mL
C. 30 mL
D. 42 mL
E. 60 mL

**8.2** During infiltration of 0.5% bupivacaine for an inguinal hernia repair, the patient complains of tingling around the lips and ringing in the ears, then has a generalised seizure. Having stopped the injection and managed the airway, what specific treatment should be given?

A. Calcium gluconate
B. Dantrolene
C. Flumazenil
D. Intravenous 20% lipid emulsion
E. Naloxone

**8.3** Twenty minutes into a laparoscopic appendicectomy under sevoflurane after suxamethonium, a 19-year-old develops tachycardia, rising end-tidal $CO_2$, masseter rigidity and a temperature of 39.5 °C. What is the specific treatment?

A. Dantrolene
B. Intravenous 20% lipid emulsion
C. Neostigmine
D. Paracetamol and active cooling only
E. Sugammadex

**8.4** A healthy 30-year-old man receives suxamethonium for an emergency appendicectomy. At the end of the operation he remains apnoeic for 2 hours, although fully anaesthetised patients normally breathe within 10 minutes. What is the most likely cause?

A. Hypokalaemia
B. Malignant hyperthermia
C. Myasthenia gravis
D. Opioid overdose
E. Plasma cholinesterase deficiency

**8.5** A 26-year-old woman has a caesarean section under spinal anaesthesia. On day 2 she has a severe frontal-occipital headache that is worse on sitting up and relieved by lying flat. Conservative measures fail. What is the definitive treatment?

A. CT scan of the brain
B. Epidural blood patch
C. Intravenous mannitol
D. Lumbar puncture to drain CSF
E. Sumatriptan

**8.6** A 70-year-old man had a thoracic epidural for laparotomy; LMWH was given 6 hours after catheter removal. Two days later he develops back pain and progressive bilateral leg weakness with urinary retention. What is the most appropriate immediate step?

A. Increase the LMWH dose
B. Nerve conduction studies
C. Observe and repeat neurological examination in 24 hours
D. Physiotherapy referral
E. Urgent MRI of the spine

**8.7** A 65-year-old man on a morphine PCA after laparotomy is found drowsy, with respiratory rate 7/min, pinpoint pupils and $SpO_2$ 89% on air. What is the most appropriate immediate drug?

A. Doxapram
B. Flumazenil
C. Naloxone
D. Neostigmine
E. Sugammadex

**8.8** A 75-year-old woman with eGFR 28 mL/min and a history of peptic ulcer has moderate pain after a hip operation. Which analgesic should be avoided?

A. Ibuprofen
B. Low-dose oral oxycodone
C. Paracetamol
D. Regional nerve block
E. Tramadol (dose-reduced)

**8.9** A 45-year-old man is to undergo emergency laparotomy for small bowel obstruction with copious nasogastric aspirates. Which anaesthetic technique minimises the risk of pulmonary aspiration at induction?

A. Awake fibreoptic intubation in all cases
B. Gas induction with sevoflurane
C. Laryngeal mask airway
D. Rapid sequence induction with cricoid pressure
E. Spinal anaesthesia alone

**8.10** A 40-year-old man is to undergo an emergency fasciotomy 10 days after sustaining 35% TBSA burns. Which neuromuscular blocking drug should be avoided because of the risk of life-threatening hyperkalaemia?

A. Atracurium
B. Cisatracurium
C. Rocuronium
D. Suxamethonium
E. Vecuronium

## Answer key with explanations

**8.1 — B** (18 mL). Maximum plain lidocaine is 3 mg/kg = 180 mg. A 1% solution contains 10 mg/mL, so 180 mg = 18 mL. With adrenaline the limit is 7 mg/kg (42 mL of 1%) — the close distractor.

**8.2 — D** (Intravenous 20% lipid emulsion). This is local anaesthetic systemic toxicity. After ABC and seizure control, 20% lipid emulsion (1.5 mL/kg bolus then infusion) is the specific antidote, particularly for bupivacaine cardiotoxicity. Dantrolene is for malignant hyperthermia.

**8.3 — A** (Dantrolene). Malignant hyperthermia: stop volatile agents, hyperventilate with 100% $O_2$, cool and give dantrolene, which inhibits calcium release from the sarcoplasmic reticulum. Cooling alone is insufficient.

**8.4 — E** (Plasma cholinesterase deficiency). Suxamethonium is metabolised by plasma (pseudo)cholinesterase; inherited deficiency causes prolonged paralysis ('scoline apnoea'). Management is continued ventilation and sedation; family testing is advised.

**8.5 — B** (Epidural blood patch). Post-dural puncture headache results from CSF leak; it is postural. Initial treatment is fluids, analgesia and caffeine; an epidural blood patch (autologous blood) seals the leak and is definitive.

**8.6 — E** (Urgent MRI of the spine). Back pain with new leg weakness after neuraxial block in an anticoagulated patient suggests an epidural haematoma (or abscess) compressing the cord; urgent MRI and surgical decompression (within ~8 h) are needed to preserve function.

**8.7 — C** (Naloxone). Opioid-induced respiratory depression is treated with oxygen, stopping the PCA and titrated IV naloxone (100–400 µg). Its short half-life may require repeated doses or infusion. Flumazenil reverses benzodiazepines.

**8.8 — A** (Ibuprofen). NSAIDs are contraindicated in significant renal impairment and peptic ulcer disease (nephrotoxicity, GI bleeding). Dose-reduced opioids and regional blocks are acceptable with monitoring.

**8.9 — D** (Rapid sequence induction with cricoid pressure). Patients with a full stomach need RSI: pre-oxygenation, rapid-onset relaxant, cricoid pressure and a cuffed tracheal tube without mask ventilation. A laryngeal mask does not protect against aspiration.

**8.10 — D** (Suxamethonium). After burns, crush or denervation injuries (from about 24–48 h), extrajunctional acetylcholine receptors proliferate; suxamethonium causes massive potassium efflux and cardiac arrest. Non-depolarising agents are used instead.

CHAPTER 9

# Care in the Operating Theatre and Principles of Minimal Access Surgery

**Key points**

- The **WHO Surgical Safety Checklist** reduces complications and deaths and is mandatory before every operation.
- Asepsis relies on theatre design, sterilisation of instruments, skin preparation and disciplined theatre behaviour.
- Patient safety in theatre includes correct positioning, safe use of **diathermy**, tourniquets and accurate swab/instrument counts.
- Laparoscopic surgery reduces pain and stay but introduces specific risks: access injury, pneumoperitoneum effects and diathermy injury.

## 1. WHO Surgical Safety Checklist

| Sign in (before induction) | Time out (before skin incision) | Sign out (before patient leaves theatre) |
|---|---|---|
| Identity, site, procedure, consent confirmed<br>Site marked<br>Anaesthesia machine and drugs checked<br>Pulse oximeter on<br>Allergies? Difficult airway/aspiration risk?<br>Risk of > 500 mL blood loss? | Team members introduce themselves<br>Confirm patient, site, procedure<br>Anticipated critical events (surgeon, anaesthetist, nurse)<br>**Antibiotic prophylaxis given within 60 min?**<br>Essential imaging displayed<br>VTE prophylaxis | Procedure recorded<br>**Instrument, swab and needle counts correct**<br>Specimens labelled<br>Equipment problems<br>Key concerns for recovery |

**Never events**: wrong-site surgery, retained foreign object, wrong implant — largely preventable by the checklist and counts.

## 2. Theatre environment and asepsis

- **Positive-pressure ventilation** (air flows out of theatre), ~20 air changes/hour; **laminar (ultraclean) flow** for orthopaedic implant surgery.
- Main source of airborne bacteria is **theatre personnel** — limit traffic and door opening.
- Surgical hand antisepsis: first scrub of the day longer; chlorhexidine or povidone-iodine, or alcohol rub.
- Skin preparation: **2% chlorhexidine in 70% alcohol** preferred (allow to dry — alcohol is flammable with diathermy).

### Sterilisation versus disinfection

| Term | Definition |
|---|---|
| Sterilisation | Destruction of **all** microorganisms including spores |
| Disinfection | Reduction of microorganisms to a safe level; spores may survive |
| Antisepsis | Disinfection of living tissue (skin) |

| Method | Details | Use |
|---|---|---|
| **Autoclave** (moist heat under pressure) | **134 °C for 3 min** or 121 °C for 15 min | Most surgical instruments — method of choice |
| Dry heat | 160 °C for 2 h | Glassware, powders, oils |
| Ethylene oxide gas | Low temperature; toxic, needs aeration | Heat-sensitive items, plastics |
| Gamma irradiation | Industrial | Single-use items (sutures, syringes, gloves) |
| Low-temperature hydrogen peroxide plasma | — | Heat-sensitive instruments |
| High-level disinfection (glutaraldehyde, peracetic acid) | Immersion | Flexible endoscopes |

> **Exam pearl — prions**
> Prions (CJD/vCJD) **resist standard sterilisation**. Use single-use instruments where possible; quarantine or destroy instruments used in high-risk tissue (brain, posterior eye, lymphoid tissue in vCJD).

## 3. Surgical diathermy

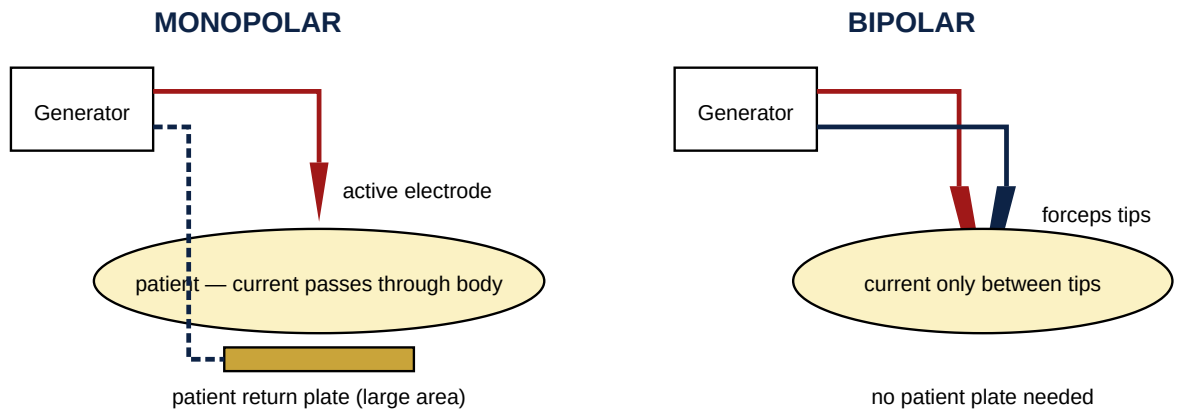



*Figure 9.1 — Monopolar versus bipolar diathermy circuits.*

| Feature | Monopolar | Bipolar |
|---|---|---|
| Circuit | Active electrode → patient → return plate | Between the two tips of forceps |
| Power | High; cutting and coagulation | Low; coagulation only |
| Safety | Risk of plate burns, distant burns, pacemaker interference, capacitive coupling | **Safer**: use for digits, penis, pedicled structures and in patients with **pacemakers** |

**Monopolar risks**: inadequate plate contact (burn at plate — place on dry, shaved, well-vascularised skin away from metal implants); alcohol skin prep fires; current channelling along narrow pedicles (e.g. testis on spermatic cord, penis) — use bipolar; in laparoscopy, **insulation failure, direct coupling and capacitive coupling** can cause unrecognised bowel burns presenting days later.

## 4. Patient positioning and tourniquets

| Position / risk | Structure at risk |
|---|---|
| Lithotomy | **Common peroneal nerve** (fibular neck against stirrup); compartment syndrome in prolonged cases |
| Arm abduction > 90° | Brachial plexus |
| Elbow pressure | Ulnar nerve |
| Prone | Eyes (pressure → blindness), face, breasts, genitalia |
| All long cases | Pressure sores over bony prominences; hypothermia |

**Tourniquet**: exsanguinate first; pressure ≈ upper limb 50–100 mmHg above systolic (~250 mmHg), lower limb ~100–150 mmHg above systolic (~300 mmHg). Limit time ≈ **1.5 h for the arm, 2 h for the leg**; record times. Contraindicated in severe peripheral vascular disease and sickle cell disease (relative).

## 5. Principles of minimal access (laparoscopic) surgery

### Advantages

- Less post-operative pain, smaller scars
- Shorter stay, faster return to work
- Reduced wound infection and incisional hernia
- Reduced metabolic response and adhesions

### Disadvantages

- Loss of tactile feedback, 2-D view (unless 3-D)
- Longer learning curve, cost
- Access injuries (bowel, major vessels)
- Effects of $CO_2$ pneumoperitoneum

| Topic | Key facts |
|---|---|
| Access | **Open (Hasson) technique** at umbilicus — fewer major vascular injuries; Veress needle (closed) — insufflation before trocar |
| Gas | **$CO_2$** — non-flammable, highly soluble (less embolic risk), cheap. Pressure typically **12–15 mmHg** |
| Physiological effects | ↑ intra-abdominal pressure → ↓ venous return, ↑ SVR, splinted diaphragm (↓ FRC, ↑ airway pressure), **hypercapnia and acidosis** from $CO_2$ absorption, reduced renal blood flow; reverse Trendelenburg worsens venous return |
| Complications | Gas embolism (sudden hypotension, "mill-wheel" murmur), surgical emphysema, pneumothorax, shoulder-tip pain (diaphragmatic irritation), port-site hernia (close fascia of ports ≥ 10 mm), port-site metastasis |
| Relative contraindications | Severe cardiopulmonary disease, uncorrected coagulopathy, multiple previous laparotomies (adhesions), advanced pregnancy |

## 6. Sharps and staff safety

- Neutral (hands-free) zone for passing sharps; never re-sheath needles; double gloving reduces exposure to blood.
- Protective eyewear; vaccination against hepatitis B for all staff.
- Smoke from diathermy and lasers should be evacuated (contains toxins and viral particles).

## Chapter 9 — Self-assessment MCQs (one best answer)

Choose the single best answer. Options are listed alphabetically.

**9.1** During the WHO Surgical Safety Checklist, at which stage should the team confirm that antibiotic prophylaxis has been given within the last 60 minutes?

A. At the end of surgery
B. Sign in
C. Sign out
D. Time out
E. When the patient arrives in recovery

**9.2** A 72-year-old man with a permanent pacemaker requires excision of a mucous cyst from his index finger. Which form of energy is safest for haemostasis?

A. Argon plasma coagulation
B. Bipolar diathermy
C. Laser
D. Monopolar diathermy in coagulation mode
E. Monopolar diathermy in cutting mode

**9.3** After a 4-hour operation in the lithotomy position, a 50-year-old woman has foot drop and loss of sensation over the dorsum of the foot. Which nerve has most likely been compressed?

A. Common peroneal nerve
B. Femoral nerve
C. Obturator nerve
D. Sciatic nerve
E. Tibial nerve

**9.4** Which method is most appropriate for sterilising standard stainless-steel surgical instruments that can withstand heat?

A. Boiling water for 10 minutes
B. Ethylene oxide
C. Gamma irradiation
D. Glutaraldehyde immersion
E. Steam autoclaving at 134 °C for 3 minutes

**9.5** Four days after an uncomplicated laparoscopic cholecystectomy, a 45-year-old woman develops peritonitis. At laparotomy a small burn perforation of the transverse colon is found away from the operative field. What is the most likely mechanism?

A. Gas embolism
B. Retained gallstone
C. Stray monopolar diathermy energy (insulation failure or capacitive coupling)
D. Trocar injury at insertion
E. Veress needle injury

**9.6** During establishment of pneumoperitoneum for laparoscopic cholecystectomy, a patient suddenly becomes hypotensive with a falling end-tidal $CO_2$ and a 'mill-wheel' murmur. What is the most likely diagnosis?

A. Anaphylaxis
B. Gas embolism
C. Tension pneumothorax
D. Vagal reaction to peritoneal stretch
E. Vascular injury with haemorrhage

**9.7** A surgeon prepares the abdomen with alcoholic chlorhexidine and immediately activates monopolar diathermy. A flash fire occurs on the drapes. What is the main preventive measure?

A. Using a lower diathermy setting
B. Using bipolar diathermy only
C. Using higher-concentration oxygen
D. Using povidone-iodine in all cases
E. Waiting for the alcoholic preparation to dry completely before draping

**9.8** Two hours into a laparoscopic operation at 15 mmHg $CO_2$ pneumoperitoneum, the anaesthetist notes rising end-tidal $CO_2$ and arterial pH 7.28 despite unchanged ventilator settings. What is the most likely explanation?

A. Malignant hyperthermia
B. Pulmonary embolism
C. Rebreathing from faulty circuit
D. Sepsis
E. Systemic absorption of insufflated $CO_2$

**9.9** A 30-year-old man undergoes a forearm tendon repair using an upper-arm pneumatic tourniquet. What is the generally accepted maximum continuous tourniquet time for the upper limb?

A. 30 minutes
B. 1.5 hours
C. 3 hours
D. 4 hours
E. 6 hours

**9.10** Following a laparoscopic sigmoid colectomy, the surgeon closes the fascia at the 12-mm extraction port but not at the 5-mm ports. What complication is being prevented?

A. Port-site hernia
B. Port-site infection
C. Port-site metastasis
D. Shoulder-tip pain
E. Surgical emphysema

## Answer key with explanations

**9.1 — D** (Time out). Antibiotic prophylaxis is confirmed at 'time out', just before skin incision, along with patient identity, site and anticipated critical events. Sign out includes counts and specimen labelling.

**9.2 — B** (Bipolar diathermy). Bipolar diathermy passes current only between the forceps tips: no return plate, no current through the body, so it is safer for digits and appendages (avoiding current channelling) and for patients with pacemakers.

**9.3 — A** (Common peroneal nerve). In lithotomy the common peroneal nerve is compressed against the stirrup at the fibular neck, causing foot drop and dorsal foot sensory loss. Sciatic nerve injury would also affect the hamstrings and tibial territory.

**9.4 — E** (Steam autoclaving at 134 °C for 3 minutes). Steam under pressure (autoclave) is the method of choice for heat-tolerant instruments. Ethylene oxide is for heat-sensitive items; gamma irradiation is industrial for single-use items; glutaraldehyde is high-level disinfection for endoscopes; boiling does not kill spores.

**9.5 — C** (Stray monopolar diathermy energy (insulation failure or capacitive coupling)). Stray monopolar energy (insulation defects, direct or capacitive coupling) can burn bowel outside the field of view; thermal necrosis perforates days later. Trocar or Veress injuries usually present earlier and are at the access site.

**9.6 — B** (Gas embolism). Gas embolism (e.g. Veress needle in a vessel) causes sudden cardiovascular collapse, a fall in $ETCO_2$ and a mill-wheel murmur. Stop insufflation, release pneumoperitoneum, place the patient head down and left side down, and aspirate via a central line if available.

**9.7 — E** (Waiting for the alcoholic preparation to dry completely before draping). Alcohol-based skin preparations are flammable; pooled or wet solution can be ignited by diathermy. The solution must be allowed to dry and pooling avoided. Increased oxygen concentration increases fire risk.

**9.8 — E** (Systemic absorption of insufflated $CO_2$). $CO_2$ is absorbed across the peritoneum, causing hypercapnia and respiratory acidosis, managed by increasing minute ventilation. Malignant hyperthermia would also cause tachycardia, rigidity and hyperthermia.

**9.9 — B** (1.5 hours). Recommended safe tourniquet times are about 1.5 hours for the upper limb and 2 hours for the lower limb, beyond which nerve and muscle injury increase. Tourniquet time should be recorded.

**9.10 — A** (Port-site hernia). Fascial defects from ports of 10 mm or more should be closed to prevent port-site (Richter's-type) hernias. Port-site metastasis is reduced by using an extraction bag, not by fascial closure.

CHAPTER 10

# Post-operative Care and Complications

**Key points**

- Post-operative complications are classified as **general** or **specific** (to the operation), and by time: **immediate, early and late**.
- Track-and-trigger systems (**NEWS2**) detect deterioration early; a score ≥ 5 needs urgent review, ≥ 7 an emergency response.
- Most early deaths after surgery are due to haemorrhage, sepsis (anastomotic leak), cardiorespiratory events and VTE.
- **Failure to rescue** — delay in recognising and treating complications — is a major cause of avoidable death.

## 1. Time course of complications

| Immediate (< 24 h) | Early (1–30 days) | Late (> 30 days) |
|---|---|---|
| Primary/reactionary haemorrhage | Pain, acute confusion | Incisional hernia |
| Airway obstruction, hypoxia | Fever, chest infection | Adhesional obstruction |
| Basal atelectasis | Wound infection, **wound dehiscence** | Hypertrophic/keloid scar |
| Hypotension / shock | **Anastomotic leak** | Recurrence of disease |
| Low urine output | Secondary haemorrhage | Chronic post-surgical pain |
| Nausea and vomiting | Paralytic ileus, urinary retention | Stoma problems |
| Myocardial infarction | **DVT / PE** | |
| | Pressure sores, *C. difficile* | |

## 2. Post-operative haemorrhage

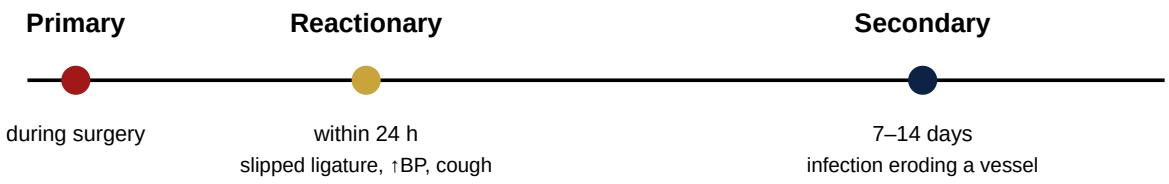



*Figure 10.1 — Timing of post-operative haemorrhage.*

**Exam pearl**

Reactionary haemorrhage after **thyroidectomy** → neck haematoma with stridor: **open the wound at the bedside** (remove skin and muscle sutures) to relieve tracheal compression, then return to theatre.

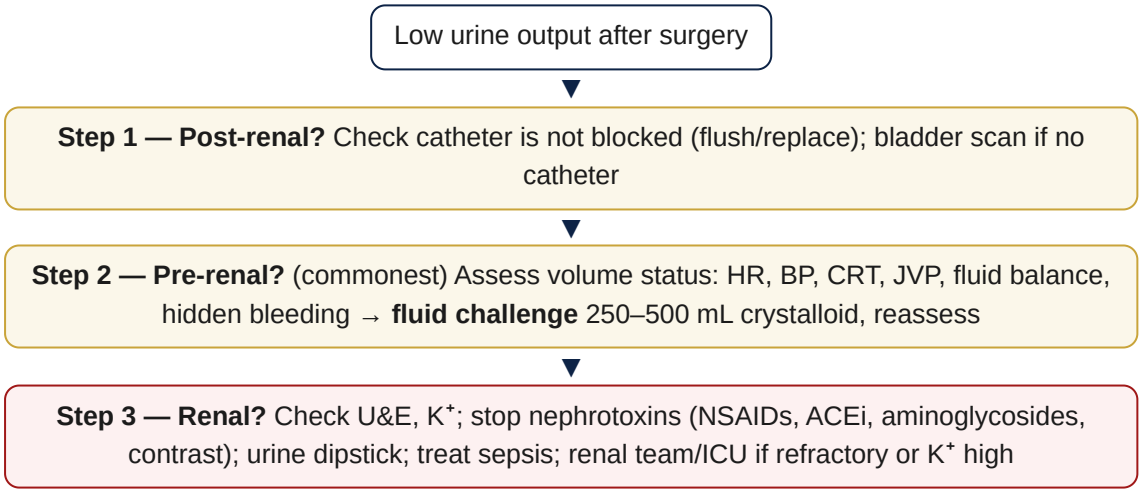
## 3. Post-operative fever

| Timing | Likely causes |
|---|---|
| Day 0–2 | Physiological (inflammatory) response, atelectasis*, transfusion reaction, early streptococcal/clostridial wound infection (rare but serious) |
| Day 3–5 | Chest infection, urinary tract infection, line infection |
| Day 5–7 | Wound infection, **anastomotic leak**, intra-abdominal abscess |
| Day 7+ | DVT/PE, collections, drug fever, *C. difficile* |

*The link between atelectasis and fever is weak; always look for infection.

**Memory aid — the "5 Ws" (approximate order)**
**W**ind (chest, day 1–2) · **W**ater (urine, day 3–5) · **W**ound (day 5–7) · **W**alking (DVT/PE, day 5+) · **W**onder drugs / **W**hat did we do (drug reactions, lines, leak).

## 4. Oliguria (< 0.5 mL/kg/h)




Avoid diuretics in a hypovolaemic oliguric patient.

## 5. Respiratory complications

- **Atelectasis**: commonest; within 48 h; pain limits deep breathing → physiotherapy, analgesia, sit up, incentive spirometry.
- **Pneumonia**: day 3–5; productive cough, fever, consolidation → antibiotics, physiotherapy.
- **Aspiration**: right lower lobe; risk with reduced consciousness and ileus.
- **ARDS**: bilateral infiltrates, hypoxaemia, not cardiogenic — sepsis, pancreatitis, massive transfusion.

## 6. Venous thromboembolism

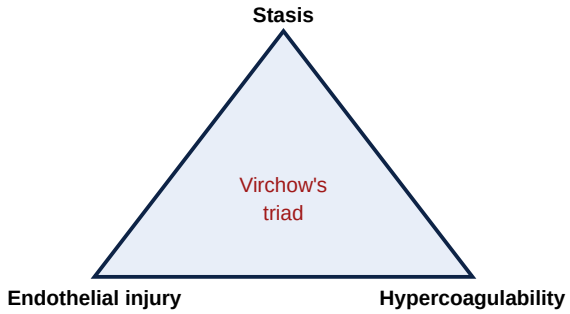



*Figure 10.2 — Virchow's triad.*

**Risk factors**: major/pelvic/orthopaedic surgery, malignancy, age > 60, obesity, immobility, previous VTE, OCP/HRT, pregnancy, thrombophilia, sepsis.

**Prophylaxis**: early mobilisation, hydration, graduated compression stockings / intermittent pneumatic compression, LMWH (e.g. enoxaparin 40 mg SC daily).

| | Deep vein thrombosis | Pulmonary embolism |
|---|---|---|
| Features | Calf pain, swelling (> 3 cm difference), warmth, pitting oedema; often silent | Sudden dyspnoea, pleuritic pain, haemoptysis, tachycardia, hypoxia; massive PE → collapse, raised JVP |
| Diagnosis | Wells score → D-dimer (if low probability; non-specific after surgery) → **compression duplex ultrasound** | **CT pulmonary angiography**; ECG (sinus tachycardia; S1Q3T3); ABG (type 1 respiratory failure) |
| Treatment | Therapeutic LMWH or DOAC (apixaban, rivaroxaban) for ≥ 3 months (provoked); **thrombolysis** for massive PE with haemodynamic instability (relative contraindication after recent surgery — consider catheter-directed therapy/embolectomy); IVC filter if anticoagulation contraindicated | |

## 7. Abdominal wound and gut complications

| Complication | Key features | Management |
|---|---|---|
| **Wound dehiscence (burst abdomen)** | Day 7–10; preceded by **serosanguinous ("pink") discharge**; risk factors: obesity, malnutrition, steroids, infection, raised intra-abdominal pressure (cough, ileus), poor technique | Reassure, cover bowel with **saline-soaked sterile packs**, analgesia, IV fluids, return to theatre for re-closure |
| **Anastomotic leak** | Day 5–7: fever, tachycardia, abdominal pain, peritonitis, ileus, raised CRP, AF, confusion; may be subclinical | Resuscitate, antibiotics, CT with contrast; small contained → percutaneous drainage; major → laparotomy, washout, stoma |
| Paralytic ileus | Absent bowel sounds, distension, vomiting, no flatus; common after laparotomy | NG decompression, IV fluids, correct $K^+$/$Mg^{2+}$, minimise opioids, exclude mechanical cause |
| Early adhesional obstruction | Colicky pain, high-pitched bowel sounds after initial return of function | Conservative initially; water-soluble contrast; surgery if not resolving |
| Urinary retention | Common after hernia/anorectal surgery, spinal anaesthesia, opioids, elderly men | Analgesia, mobilise, catheterise |

## 8. Acute post-operative confusion (delirium)

Common in the elderly. Look for and treat causes: **hypoxia, sepsis, hypoglycaemia, electrolyte disturbance, drugs (opioids, anticholinergics), alcohol withdrawal, urinary retention, constipation, pain, MI, stroke**. Non-pharmacological measures first (orientation, glasses/hearing aids, sleep, family); low-dose haloperidol only if distressed or unsafe.

## Chapter 10 — Self-assessment MCQs (one best answer)

Choose the single best answer. Options are listed alphabetically.

**10.1** Eight days after a midline laparotomy for perforated diverticulitis, a 68-year-old obese man notices a large amount of pink serous fluid soaking his dressing. He is otherwise stable. What is the most likely diagnosis?

A. Anastomotic leak
B. Impending wound dehiscence
C. Seroma
D. Superficial wound infection
E. Wound haematoma

**10.2** The patient in the previous question is examined and loops of small bowel are visible in the wound. What is the immediate management on the ward?

A. Apply a vacuum dressing and observe
B. Cover the bowel with sterile saline-soaked packs and arrange return to theatre
C. Insert a nasogastric tube and observe for 48 hours
D. Push the bowel back in and apply an abdominal binder
E. Re-suture the skin at the bedside under local anaesthesia

**10.3** Six days after an anterior resection, a 60-year-old man has new atrial fibrillation, temperature 38.4 °C, tachycardia, lower abdominal pain and CRP rising to 280 mg/L. What is the most likely diagnosis?

A. Anastomotic leak
B. Clostridioides difficile colitis
C. Myocardial infarction
D. Pulmonary embolism
E. Urinary tract infection

**10.4** Four hours after a total thyroidectomy, a 45-year-old woman develops increasing neck swelling, stridor and distress. Oxygen saturation is falling. What is the most appropriate immediate action?

A. Call for CT scan of the neck
B. Give intravenous calcium gluconate
C. Give nebulised adrenaline and observe
D. Open the skin and strap-muscle sutures at the bedside
E. Perform urgent tracheostomy

**10.5** Twelve days after a tonsillectomy, a 25-year-old man presents with bleeding from the tonsillar fossa, fever and foul breath. What type of haemorrhage is this?

A. Delayed primary haemorrhage
B. Primary haemorrhage
C. Reactionary haemorrhage
D. Secondary haemorrhage
E. Tertiary haemorrhage

**10.6** A 70-year-old man has passed only 60 mL of urine over 3 hours, 8 hours after a laparotomy. He has a urinary catheter. HR 105/min, BP 105/70 mmHg, cool peripheries. What is the first step?

A. Check and flush the urinary catheter
B. Give intravenous furosemide
C. Request a renal ultrasound
D. Start a dopamine infusion
E. Urgent haemodialysis

**10.7** Nine days after a total hip replacement, a 66-year-old woman suddenly becomes breathless with pleuritic chest pain. HR 118/min, BP 124/78 mmHg, $SpO_2$ 90% on air; ECG shows sinus tachycardia. What is the most appropriate diagnostic investigation?

A. Chest X-ray
B. CT pulmonary angiography
C. D-dimer
D. Echocardiography
E. Lower-limb duplex ultrasound

**10.8** A 32-year-old woman has severe pain and cannot pass urine 6 hours after an open haemorrhoidectomy under spinal anaesthesia. Her bladder is palpable to the umbilicus. What is the most appropriate management?

A. Bethanechol
B. Bladder catheterisation
C. Encourage oral fluids and wait
D. Intravenous furosemide
E. Tamsulosin and review the next day

**10.9** A 78-year-old man becomes acutely agitated and disoriented on the second night after a hernia repair. He was alert pre-operatively. Which is the first priority?

A. Arrange CT of the brain
B. Give intramuscular haloperidol
C. Identify and treat an underlying cause such as hypoxia, sepsis or retention
D. Restrain him to prevent falls
E. Transfer to a psychiatric unit

**10.10** Three days after laparotomy a patient has abdominal distension, absent bowel sounds, effortless vomiting and no flatus. There is no colicky pain. Serum $K^+$ is 2.9 mmol/L. Which is the most likely diagnosis?

A. Acute gastric dilatation only
B. Adhesional small-bowel obstruction
C. Anastomotic leak
D. Paralytic ileus
E. Pseudo-obstruction of the colon

## Answer key with explanations

**10.1 — B** (Impending wound dehiscence). Serosanguinous ('salmon-pink') discharge around day 7–10 is the classic warning sign of fascial dehiscence (burst abdomen). A seroma is straw-coloured and usually localised; an anastomotic leak presents with sepsis and peritonitis.

**10.2 — B** (Cover the bowel with sterile saline-soaked packs and arrange return to theatre). Burst abdomen: reassure, cover the eviscerated bowel with warm sterile saline-soaked packs, give analgesia and IV fluids, and arrange urgent re-closure in theatre. Bedside re-suturing or pushing the bowel back is inappropriate.

**10.3 — A** (Anastomotic leak). Day 5–7 sepsis with abdominal pain and a markedly raised CRP after colorectal surgery suggests anastomotic leak; new AF and confusion are common early signs. Urgent CT with contrast is required.

**10.4 — D** (Open the skin and strap-muscle sutures at the bedside). Reactionary haemorrhage causing tension haematoma can obstruct the airway; immediate decompression by opening the wound at the bedside is life-saving, followed by return to theatre. Hypocalcaemia presents later (24–48 h) with tingling, not neck swelling.

**10.5 — D** (Secondary haemorrhage). Secondary haemorrhage occurs 7–14 days after surgery, usually due to infection eroding a vessel. Reactionary haemorrhage occurs within 24 hours (slipped ligature, rising BP).

**10.6 — A** (Check and flush the urinary catheter). The first step in post-operative oliguria is to exclude a blocked catheter (post-renal cause), then assess volume status and give a fluid challenge for the likely pre-renal cause. Furosemide in a hypovolaemic patient is harmful.

**10.7 — B** (CT pulmonary angiography). With high clinical probability of PE, CTPA is the definitive test. D-dimer is non-specific after surgery and useful only to exclude VTE when probability is low. Treatment-dose anticoagulation should be started while awaiting imaging.

**10.8 — B** (Bladder catheterisation). Acute retention after anorectal surgery and spinal anaesthesia is common. With a palpable, painful bladder, catheterisation is required; simple measures (analgesia, mobilisation) are tried only before the bladder is overdistended.

**10.9 — C** (Identify and treat an underlying cause such as hypoxia, sepsis or retention). Post-operative delirium is usually due to a correctable cause: check oxygenation, glucose, electrolytes, sepsis, drugs, urinary retention, constipation and pain. Sedation is used only if he is a danger to himself or others; restraint worsens delirium.

**10.10 — D** (Paralytic ileus). Silent, distended abdomen with vomiting and no colic early after laparotomy is paralytic ileus, worsened by hypokalaemia and opioids. Mechanical adhesional obstruction typically causes colicky pain with tinkling bowel sounds after function has returned.

CHAPTER 11

# Early Assessment and Management of Trauma

**Key points**

- Trauma is the leading cause of death in young adults. Management follows the **ATLS** principle: **treat the greatest threat to life first**.
- **Primary survey** (<C>ABCDE) with simultaneous resuscitation → adjuncts → **secondary survey** (head-to-toe) → definitive care.
- Lack of a definitive diagnosis should never delay a life-saving intervention.
- Haemorrhage is the leading **preventable** cause of death after injury.

## 1. Trimodal distribution of trauma deaths

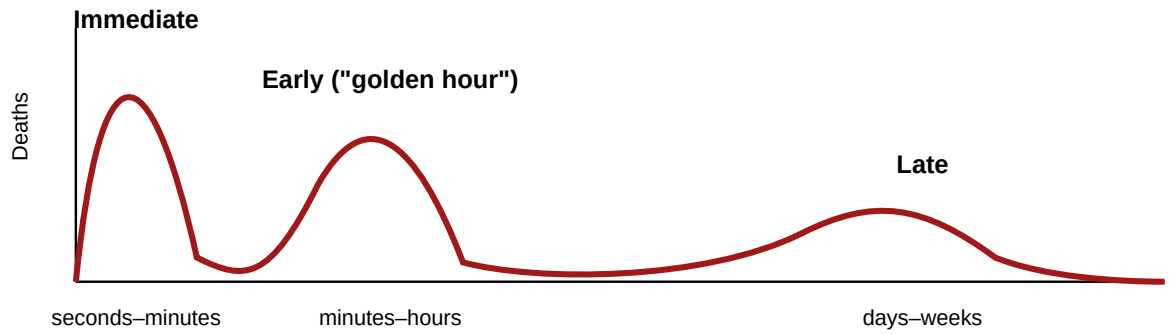



*Figure 11.1 — Trimodal distribution of trauma deaths.*

| Peak | Causes | Prevention |
|---|---|---|
| Immediate | Severe brain/high spinal cord injury, rupture of heart/aorta | Injury prevention (seat belts, helmets) |
| Early | Haemorrhage (chest, abdomen, pelvis, long bones), airway compromise, tension pneumothorax, extradural haematoma | **ATLS** — rapid assessment and resuscitation |
| Late | Sepsis, MODS, PE | Good critical care |

## 2. The primary survey

**<C> Catastrophic external haemorrhage** — direct pressure, tourniquet, haemostatic dressing

▼

**A — Airway with cervical spine protection**: talk to patient; chin lift/jaw thrust, suction, adjuncts; definitive airway if GCS ≤ 8, burns, apnoea, unprotectable airway; **surgical cricothyroidotomy** if cannot intubate/oxygenate; manual in-line stabilisation

▼

**B — Breathing and ventilation**: high-flow $O_2$; look, feel, percuss, listen; identify and treat life threats (table below)

▼

**C — Circulation with haemorrhage control**: two large-bore cannulae; bloods + cross-match; warmed fluids, early blood; pelvic binder; splint long bones; look for bleeding "**on the floor and four more**"

▼

**D — Disability**: GCS, pupils, lateralising signs, glucose

▼

**E — Exposure / Environment**: fully undress, log-roll, then prevent **hypothermia**

▼

**Adjuncts**: ECG, $SpO_2$, $ETCO_2$, ABG, urinary and gastric catheters*, CXR and pelvic X-ray, **eFAST** → CT if haemodynamically stable

*Do not insert a urinary catheter if urethral injury is suspected (blood at the meatus, perineal haematoma, high-riding prostate) — or a nasogastric tube with suspected basal skull fracture (use the orogastric route).

**Sources of major blood loss — "on the floor and four more"**
External (floor) · Chest · Abdomen · Pelvis/retroperitoneum · Long bones (femur ~1–1.5 L each)

## 3. Life-threatening chest injuries (identify in primary survey)

| Condition | Clinical features | Immediate treatment |
|---|---|---|
| **Tension pneumothorax** | Respiratory distress, hypotension, tracheal deviation **away**, absent breath sounds, hyper-resonance, distended neck veins — **clinical diagnosis, no X-ray** | Needle decompression (adults: 4th/5th ICS, just anterior to mid-axillary line; or 2nd ICS mid-clavicular) or finger thoracostomy → chest drain |
| Open pneumothorax | "Sucking" chest wound | Three-sided occlusive dressing → chest drain away from wound |
| **Massive haemothorax** | Shock, dull percussion, absent breath sounds | Chest drain + blood; **thoracotomy if > 1500 mL initially or > 200 mL/h for 2–4 h** |
| Flail chest | ≥ 2 adjacent ribs broken in ≥ 2 places; paradoxical movement; underlying **pulmonary contusion** causes hypoxia | $O_2$, analgesia (epidural/blocks), ventilation if needed, rib fixation |
| **Cardiac tamponade** | **Beck's triad**: hypotension, raised JVP, muffled heart sounds; pulsus paradoxus; penetrating injury | FAST confirms; **thoracotomy/sternotomy** (pericardiocentesis only as temporising measure) |
| Airway obstruction / tracheobronchial injury | Stridor, surgical emphysema, persistent air leak | Definitive airway, surgery |

## 4. Glasgow Coma Scale

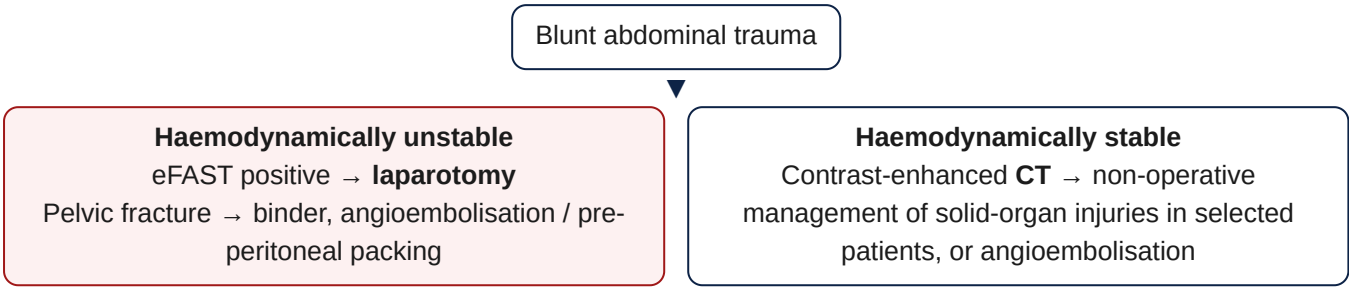
| Eye opening (E) | Verbal response (V) | Motor response (M) |
|---|---|---|
| 4 Spontaneous<br>3 To sound/voice<br>2 To pressure/pain<br>1 None | 5 Oriented<br>4 Confused<br>3 Inappropriate words<br>2 Incomprehensible sounds<br>1 None | 6 Obeys commands<br>5 Localises<br>4 Normal flexion (withdraws)<br>3 Abnormal flexion (decorticate)<br>2 Extension (decerebrate)<br>1 None |

Head injury severity: **mild 13–15, moderate 9–12, severe ≤ 8** (intubate). Score range 3–15.

| Feature | Extradural haematoma | Acute subdural haematoma |
|---|---|---|
| Vessel | Middle meningeal artery (temporal bone fracture) | Bridging veins |
| Clinical | Classic **lucid interval** then rapid deterioration, ipsilateral fixed dilated pupil | Elderly, alcoholics, anticoagulated; often severe primary brain injury |
| CT | **Biconvex (lentiform)**, limited by sutures | **Crescentic**, crosses sutures |
| Outcome | Excellent if evacuated early | Worse prognosis |

**Cushing's reflex** (raised ICP): hypertension, bradycardia, irregular respiration — a late, pre-terminal sign.

## 5. Abdominal and pelvic trauma




Penetrating abdominal trauma with shock, peritonitis or evisceration → laparotomy.

## 6. Damage-control surgery

For the physiologically exhausted patient (hypothermia, acidosis, coagulopathy): an abbreviated operation to **stop bleeding and control contamination** (packing, shunts, stapling bowel ends), temporary abdominal closure → ICU to restore physiology → planned re-look and definitive repair at 24–48 h.

## 7. Secondary and tertiary survey

- **Secondary survey**: only after primary survey is complete and resuscitation is under way — full head-to-toe examination, log-roll, PR/PV where indicated, **AMPLE** history: **A**llergies, **M**edications, **P**ast history/**P**regnancy, **L**ast meal, **E**vents/environment.
- **Tertiary survey**: repeat full examination within 24 h to detect missed injuries (commonly hands, feet, small fractures).

## Chapter 11 — Self-assessment MCQs (one best answer)

Choose the single best answer. Options are listed alphabetically.

**11.1** A 25-year-old motorcyclist is brought in after a collision. He is agitated, $SpO_2$ 84%, BP 80/50 mmHg, trachea deviated to the left, absent breath sounds and hyper-resonance on the right, with distended neck veins. What is the immediate management?

A. Chest X-ray
B. Endotracheal intubation
C. Needle decompression of the right chest
D. Pericardiocentesis
E. Right intercostal drain after CT scan

**11.2** A 30-year-old man with a stab wound to the left parasternal region has BP 75/50 mmHg, distended neck veins, muffled heart sounds and clear, equal breath sounds. FAST shows pericardial fluid. What is the definitive treatment?

A. Bilateral chest drains
B. Needle pericardiocentesis alone
C. Rapid infusion of 2 L crystalloid
D. Resuscitative thoracotomy or sternotomy
E. Tension pneumothorax decompression

**11.3** Following blunt chest trauma, a chest drain is inserted in a 40-year-old man and immediately drains 1700 mL of blood. He remains hypotensive. What is the most appropriate next step?

A. Clamp the chest drain
B. CT of the chest
C. Insert a second chest drain
D. Observe drain output hourly for 4 hours
E. Thoracotomy

**11.4** A pedestrian hit by a car opens his eyes only to pain, makes incomprehensible sounds and withdraws his limb from a painful stimulus. What is his Glasgow Coma Score?

A. 6
B. 7
C. 8
D. 9
E. 10

**11.5** A 22-year-old man is hit on the side of the head by a cricket ball. He is briefly unconscious, then talks normally for 2 hours before becoming drowsy with a dilated right pupil. CT shows a biconvex hyperdense collection. What is the source of bleeding?

A. Bridging veins
B. Circle of Willis aneurysm
C. Middle cerebral artery
D. Middle meningeal artery
E. Superior sagittal sinus

**11.6** A 35-year-old man is involved in a motor-vehicle collision. He has blood at the urethral meatus and a perineal haematoma; pelvic X-ray shows a pelvic ring fracture. Which action should be avoided in the primary survey?

A. Application of a pelvic binder
B. Blind urethral catheterisation
C. Cross-matching blood
D. eFAST scan
E. Two large-bore IV cannulae

**11.7** After a road traffic collision, a 40-year-old woman has BP 82/50 mmHg and pulse 130/min despite 2 units of blood. eFAST shows free fluid in Morison's pouch. Her chest and pelvic X-rays are normal. What is the next step?

A. Contrast CT of the abdomen
B. Diagnostic peritoneal lavage
C. Exploratory laparotomy
D. Further crystalloid and observe
E. Repeat FAST in 30 minutes

**11.8** A 28-year-old man has multiple rib fractures with a segment of the chest wall moving inward on inspiration. His oxygen saturation is 88% despite high-flow oxygen. What is the main cause of his hypoxia?

A. Haemothorax
B. Paradoxical movement of the flail segment
C. Pneumothorax
D. Pulmonary contusion beneath the flail segment
E. Splinting due to pain alone

**11.9** A 50-year-old man has damage-control laparotomy for liver and small-bowel injuries; he is hypothermic (34 °C), pH 7.1 and coagulopathic. The bleeding is packed and the bowel ends are stapled. What is the next phase of care?

A. Definitive anastomosis and abdominal closure immediately
B. Discharge to the ward
C. ICU resuscitation to correct physiology, then planned re-look at 24–48 h
D. Primary fascial closure under tension
E. Transfer for CT of the abdomen

**11.10** A 19-year-old man has a single stab wound to the abdomen. He is haemodynamically stable but has generalised peritonitis on examination. What is the most appropriate management?

A. Contrast CT of the abdomen
B. Diagnostic laparoscopy
C. Laparotomy
D. Local wound exploration
E. Serial clinical examination

## Answer key with explanations

**11.1 — C** (Needle decompression of the right chest). This is a right tension pneumothorax — a clinical diagnosis requiring immediate decompression (needle or finger thoracostomy) followed by a chest drain. Waiting for an X-ray or CT is dangerous.

**11.2 — D** (Resuscitative thoracotomy or sternotomy). Beck's triad with positive FAST after penetrating injury indicates cardiac tamponade. Definitive treatment is surgical decompression and repair of the cardiac wound; pericardiocentesis is only a temporising measure.

**11.3 — E** (Thoracotomy). Initial drainage of more than 1500 mL (or more than 200 mL/h for 2–4 h) with ongoing instability is an indication for thoracotomy. Clamping the drain is not appropriate in trauma.

**11.4 — C** (8). E2 (pain) + V2 (incomprehensible sounds) + M4 (withdrawal/normal flexion) = 8. A GCS of 8 or less indicates severe head injury and the need for a definitive airway.

**11.5 — D** (Middle meningeal artery). Extradural haematoma — temporal bone fracture tearing the middle meningeal artery, lucid interval, biconvex (lentiform) collection limited by sutures. Bridging veins cause crescentic subdural haematomas.

**11.6 — B** (Blind urethral catheterisation). Blood at the meatus, perineal haematoma or a high-riding prostate suggest urethral injury; a blind urethral catheter may convert a partial into a complete tear. A retrograde urethrogram or suprapubic catheter is used instead.

**11.7 — C** (Exploratory laparotomy). A haemodynamically unstable patient with a positive FAST needs immediate laparotomy for haemorrhage control. CT is reserved for haemodynamically stable patients — taking an unstable patient to CT is dangerous.

**11.8 — D** (Pulmonary contusion beneath the flail segment). Although paradoxical movement is striking, hypoxia in flail chest results mainly from the underlying pulmonary contusion; pain-related hypoventilation contributes. Treatment is oxygen, analgesia, and ventilation if needed.

**11.9 — C** (ICU resuscitation to correct physiology, then planned re-look at 24–48 h). Damage control: abbreviated surgery → ICU to correct the lethal triad (warming, blood products, acidosis correction) → planned return for definitive repair once physiology is restored. Definitive anastomosis in the acidotic, cold patient is unsafe.

**11.10 — C** (Laparotomy). Penetrating abdominal trauma with peritonitis, shock or evisceration requires laparotomy. Selective non-operative management with CT or serial examination applies only to stable patients without peritonitis.

CHAPTER 12

# Burns

**Key points**

- A burn is a **coagulative destruction** of skin and underlying tissue by heat, chemicals, electricity, radiation or friction.
- The three key assessments: **airway (inhalation injury), extent (% TBSA) and depth**.
- Burns > 15% TBSA in adults (> 10% in children) need **formal IV fluid resuscitation**.
- Major causes of death: early — airway/inhalation injury and burn shock; late — **sepsis and MODS**.

## 1. Pathophysiology — Jackson's burn wound model

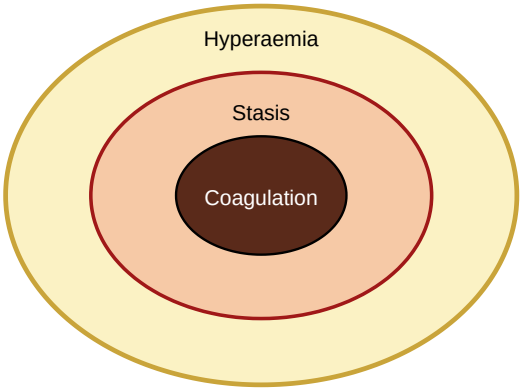



*Figure 12.1 — Jackson's zones of a burn.*

| Zone | Features |
|---|---|
| Coagulation | Central; irreversible necrosis |
| **Stasis** | Reduced perfusion; **salvageable** — can be lost with hypovolaemia, infection, oedema → aim of resuscitation |
| Hyperaemia | Outer; vasodilatation; recovers |

In burns > 25–30% TBSA, inflammatory mediators cause a **systemic** capillary leak, hypovolaemia (burn shock) and hypermetabolism.

## 2. Assessment of extent (% total body surface area)

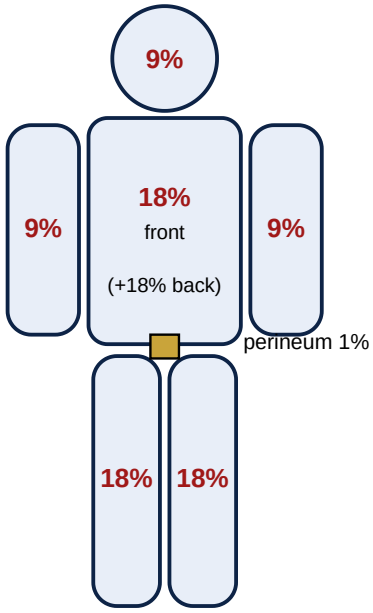



*Figure 12.2 — Wallace's rule of nines (adult).*

| Region (adult) | % TBSA |
|---|---|
| Head and neck | 9 |
| Each upper limb | 9 |
| Anterior trunk | 18 |
| Posterior trunk | 18 |
| Each lower limb | 18 |
| Perineum | 1 |

- **Palmar method**: the patient's palm *including fingers* ≈ **1%** TBSA — for small or scattered burns.
- **Lund and Browder chart**: most accurate; essential in **children** (relatively larger head, smaller legs; infant head ≈ 18%).
- Do **not** include simple erythema (superficial epidermal burns) in % TBSA.

## 3. Depth of burn

| Depth | Appearance | Sensation | Capillary refill | Healing |
|---|---|---|---|---|
| Superficial (epidermal) | Red, dry, no blisters (e.g. sunburn) | Painful | Present | ~7 days, no scar |
| Superficial partial-thickness (dermal) | Pink, moist, **blisters** | **Very painful** | Brisk | ~10–14 days, minimal scar |
| Deep partial-thickness (dermal) | Mottled red/white, dry, fixed staining | Reduced | Sluggish / absent | > 3 weeks; hypertrophic scarring → usually excise and graft |
| **Full thickness** | White, waxy, leathery or charred; thrombosed vessels | **Painless** (insensate) | Absent | Does not heal (except small, from edges) → **excision and grafting** |

## 4. Emergency management

**First aid**: stop the burning process · remove clothing/jewellery · **cool with running tap water for 20 min** (useful up to 3 h after burn) · cover with cling film · keep the patient warm

▼

**A** — airway with C-spine control: look for inhalation injury → early intubation

▼

**B** — breathing: 100% $O_2$ (CO poisoning); circumferential chest burn → **escharotomy**

▼

**C** — circulation: two large-bore cannulae (through burnt skin if necessary); start fluid resuscitation; urinary catheter

▼

**D, E** — GCS; expose, estimate % TBSA and depth; prevent hypothermia; analgesia (IV opioid); tetanus

▼

Refer to burns unit if criteria met

### Inhalation injury — suspect if:

- Burns in an enclosed space
- Facial burns, singed nasal hair/eyebrows
- Soot in mouth/nose, **carbonaceous sputum**
- **Hoarse voice, stridor**, brassy cough
- Respiratory distress, altered consciousness
- Raised carboxyhaemoglobin

Airway oedema progresses over hours — **intubate early** with an uncut tube. **Carbon monoxide poisoning**: pulse oximetry falsely normal; "cherry-red" colour is unreliable; measure COHb on blood gas; treat with **100% oxygen** (half-life of COHb falls from ~4 h to ~1 h); consider hyperbaric $O_2$. Also consider **cyanide** poisoning (house fires — plastics) with unexplained lactic acidosis → hydroxocobalamin.

## 5. Fluid resuscitation — Parkland formula

**Parkland formula**

Total fluid in first 24 h = **4 mL × body weight (kg) × % TBSA** (Hartmann's solution)

• Give **half in the first 8 hours from the time of burn** (not from arrival), half over the next 16 hours.

• Children: add **maintenance fluid** with dextrose.

• Titrate to **urine output: 0.5 mL/kg/h in adults, 1 mL/kg/h in children** (1–1.5 mL/kg/h in electrical burns with myoglobinuria).

**Worked example**: 70-kg man, 30% TBSA at 10:00, arrives 12:00 → 4 × 70 × 30 = 8400 mL; 4200 mL by 18:00 (i.e. over the remaining 6 h = 700 mL/h), then 4200 mL over the next 16 h (≈ 262 mL/h). Avoid over-resuscitation ("fluid creep") — compartment syndromes, pulmonary oedema.

## 6. Special burns

| Type | Key points |
|---|---|
| Electrical | Small entry/exit wounds hide extensive deep muscle damage; **cardiac arrhythmias** (ECG monitoring); **rhabdomyolysis, myoglobinuria** → AKI (higher urine output target, ± alkalinisation); compartment syndrome → fasciotomy; high voltage > 1000 V |
| Chemical | Remove contaminated clothing; **copious irrigation with water** for prolonged periods; **alkalis penetrate deeper** than acids (liquefactive necrosis); **hydrofluoric acid** → hypocalcaemia — topical/IV calcium gluconate; eye injuries → irrigate and ophthalmology |
| Circumferential full thickness | Rigid eschar constricts limb (ischaemia) or chest (ventilation) → **escharotomy** along mid-lateral/medial lines |
| Non-accidental injury | Delay in presentation, inconsistent history, glove/stocking scalds with clear margins, cigarette burns — child protection referral |

## 7. Referral to a burns unit (typical criteria)

- > 3% TBSA partial thickness in adults (> 2% children); any full-thickness burn (unit policies vary)
- Burns to **face, hands, feet, genitalia, perineum, major joints**; circumferential burns
- Inhalation, electrical and chemical burns; extremes of age; significant comorbidity; suspected non-accidental injury

## 8. Later management and complications

| Issue | Key facts |
|---|---|
| Wound care | Superficial: dressings (non-adherent, silver). Deep: **early tangential excision and split-thickness skin grafting** (meshed for large burns); full-thickness grafts for face/hands where possible |
| Hypermetabolism | Early **enteral feeding** (within 24 h), high protein; propranolol, oxandrolone in severe burns |
| Infection | Leading cause of late death; *Pseudomonas*, *Staph. aureus*; no routine prophylactic antibiotics |
| GI | **Curling's ulcer** (stress ulcer of duodenum) — PPI prophylaxis |
| Scarring | Hypertrophic scars, contractures across joints (splint, pressure garments, physiotherapy); **Marjolin's ulcer** in chronic burn scar |
| Other | Compartment syndrome, AKI, ARDS, VTE, psychological sequelae |

## Chapter 12 — Self-assessment MCQs (one best answer)

Choose the single best answer. Options are listed alphabetically.

**12.1** A 70-kg man sustains 30% TBSA deep partial- and full-thickness flame burns at 08:00 and arrives at hospital at 10:00. Using the Parkland formula, how much Hartmann's solution should he receive between 10:00 and 16:00?

A. 2100 mL
B. 4200 mL
C. 6300 mL
D. 8400 mL
E. 12 600 mL

**12.2** A 4-year-old child has scalds to the head and anterior trunk. Which method is most accurate for estimating the % TBSA burned?

A. Lund and Browder chart
B. Palmar method using the examiner's hand
C. Rule of nines (adult)
D. Rule of tens
E. Serial photography

**12.3** A house-fire victim has facial burns, singed nasal hair, soot in the mouth and a hoarse voice. $SpO_2$ is 98% on air. He is talking. What is the most appropriate airway management?

A. Chest X-ray and observe
B. Early endotracheal intubation
C. Nasopharyngeal airway
D. Nebulised adrenaline and review in 4 hours
E. Oxygen by face mask only, as saturations are normal

**12.4** A man rescued from a burning room is confused with a headache. His $SpO_2$ reads 99% on room air, yet he looks unwell. What is the most appropriate immediate treatment?

A. 100% oxygen via a non-rebreathing mask
B. Hyperbaric oxygen before any other treatment
C. Intravenous methylene blue
D. Oxygen titrated to $SpO_2$ 94–98%
E. Sodium bicarbonate

**12.5** A burn on the forearm is white and leathery, with no blanching and no pain to pinprick. What is the depth of this burn?

A. Deep partial-thickness
B. Full thickness
C. Mid-dermal partial-thickness
D. Superficial epidermal
E. Superficial partial-thickness

**12.6** A 35-year-old man has circumferential full-thickness burns of the left forearm. Six hours after admission the hand is cold and pale with reduced capillary refill and weak radial pulse. What is the most appropriate treatment?

A. Elevation and observation
B. Escharotomy
C. Fasciotomy as first procedure
D. Increase IV fluids
E. Urgent split-skin grafting

**12.7** An electrician receives a high-voltage injury with small entry and exit wounds on the hand and foot. His urine is dark brown and dipstick-positive for blood, but microscopy shows no red cells. What is the main aim of fluid management?

A. Fluid restriction to prevent oedema
B. Parkland formula based on visible skin burn only
C. Restrict potassium-containing fluids only
D. Target urine output of 0.5 mL/kg/h
E. Target urine output of about 1–1.5 mL/kg/h to clear myoglobin

**12.8** A factory worker spills a strong alkali on his forearm. What is the most appropriate first-aid measure?

A. Apply a neutralising acid solution
B. Apply calcium gluconate gel
C. Apply cling film and transfer immediately
D. Copious irrigation with running water for a prolonged period
E. Cover with a dry dressing and give analgesia

**12.9** Ten days after 45% TBSA burns, a patient in the burns unit has haematemesis and melaena. Endoscopy shows an acute duodenal ulcer. What is the name of this condition?

A. Cameron lesion
B. Curling's ulcer
C. Cushing's ulcer
D. Dieulafoy lesion
E. Mallory–Weiss tear

**12.10** A 25-year-old woman has a scald from boiling water. The burn is pink, moist and blistered, blanches briskly and is exquisitely painful. How is it expected to heal with good dressings?

A. Heals within 7 days without blistering
B. Requires excision and grafting
C. Spontaneous healing in about 10–14 days with minimal scarring
D. Takes more than 3 weeks and causes hypertrophic scarring
E. Will never heal without grafting

## Answer key with explanations

**12.1 — B** (4200 mL). Total = 4 × 70 × 30 = 8400 mL; half (4200 mL) is due in the first 8 hours from the time of injury (08:00–16:00). As 2 hours have passed without fluid, the full 4200 mL is given between 10:00 and 16:00.

**12.2 — A** (Lund and Browder chart). Children have proportionately larger heads and smaller legs, so the adult rule of nines is inaccurate; the Lund and Browder chart adjusts for age. The palmar method uses the patient's (not the examiner's) palm.

**12.3 — B** (Early endotracheal intubation). Signs of inhalation injury with hoarseness mean progressive airway oedema is likely; early intubation is safer before the airway becomes impossible to secure. Normal oximetry is unreliable (CO poisoning).

**12.4 — A** (100% oxygen via a non-rebreathing mask). Suspected carbon monoxide poisoning: pulse oximetry cannot distinguish COHb from oxyhaemoglobin and is falsely normal. Give 100% $O_2$ immediately (reduces COHb half-life) and measure COHb; hyperbaric $O_2$ is considered later in selected cases.

**12.5 — B** (Full thickness). Full-thickness burns are white/waxy or leathery, non-blanching and insensate because nerve endings are destroyed. Deep partial-thickness burns are mottled with reduced but present sensation — the close distractor.

**12.6 — B** (Escharotomy). Inelastic eschar of a circumferential full-thickness burn constricts the limb as oedema develops; escharotomy (incising the eschar along mid-medial/lateral lines) restores perfusion. Fasciotomy is needed only if a deeper compartment syndrome persists (e.g. electrical burns).

**12.7 — E** (Target urine output of about 1–1.5 mL/kg/h to clear myoglobin). Myoglobinuria from muscle necrosis risks acute kidney injury; higher urine output (≈ 1–1.5 mL/kg/h) is targeted. The Parkland formula underestimates needs because skin burns understate deep muscle damage.

**12.8 — D** (Copious irrigation with running water for a prolonged period). Chemical burns are treated with prolonged, copious irrigation; alkalis penetrate deeply (liquefactive necrosis) and need longer irrigation. Neutralising agents generate heat and are avoided. Calcium gluconate is specific for hydrofluoric acid.

**12.9 — B** (Curling's ulcer). Curling's ulcer is a stress ulcer (usually duodenal) after major burns, prevented by early enteral feeding and PPI prophylaxis. Cushing's ulcer follows head injury/raised ICP — the close eponymous distractor.

**12.10 — C** (Spontaneous healing in about 10–14 days with minimal scarring). Superficial partial-thickness (superficial dermal) burns are blistered, moist, very painful with brisk refill and heal from adnexal remnants in about 2 weeks with little scarring. Deep dermal burns take more than 3 weeks and scar.